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Ballantine

MP MASTER
MA31987

INSTRUCTION MANUAL

(MODELS 323 AND 323-01)

With
Addendum For
Models 323-06, 323-07
Models 323-20, 323-21
and
"L" Models

323 SERIES TRUE RMS VOLTMETERS

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90900011D

APRIL 1981

WARRANTY

This Ballantine Laboratories, Inc. product is warranted against defects in materials and workmanship for a period of one year from the date of shipment, except for batteries, electron tubes, vacuum thermocouples, and certain other components, if any, listed in this manual. Ballantine Laboratories, Inc. will, at its option, repair or replace products which prove to be defective during the warranty period provided they are returned to Ballantine Laboratories, Inc. prepaid, and provided the proper preventive maintenance and calibration procedures as listed in this manual have been followed. Repairs necessitated by misuse of the product are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. BALLANTINE LABORATORIES, INC. IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

CERTIFICATION

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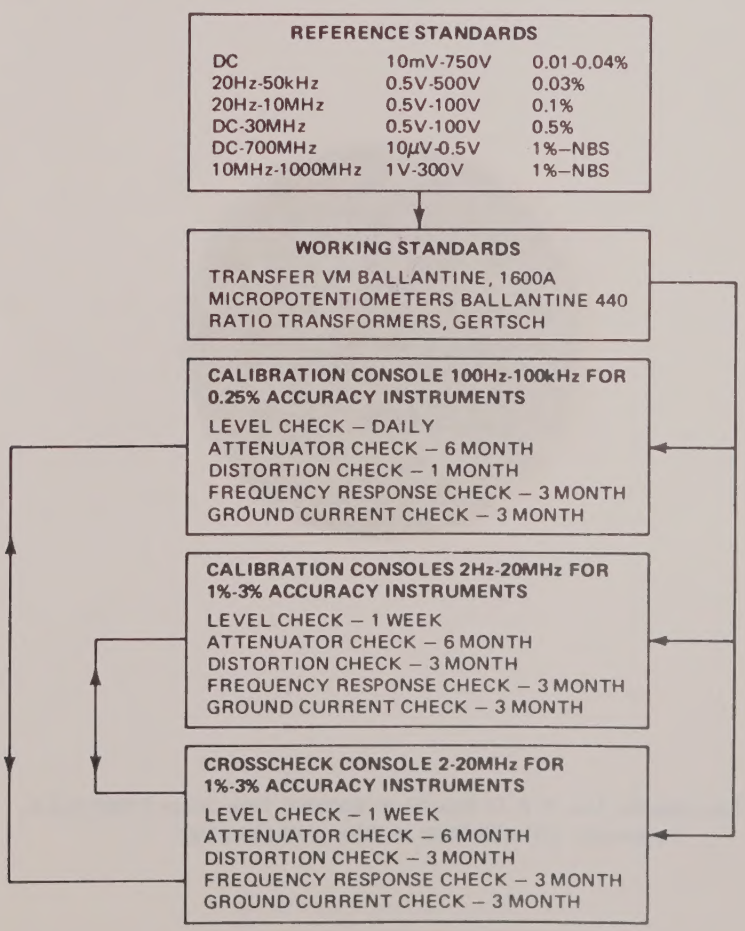
REFERENCE STANDARDS
DC 10mV-750V 0.01-0.04%
20Hz-50kHz 0.5V-500V 0.03%
20Hz-10MHz 0.5V-100V 0.1%
DC-30MHz 0.5V-100V 0.5%
DC-700MHz 10μV-0.5V 1%–NBS
10MHz-1000MHz 1V-300V 1%–NBS
WORKING STANDARDS
TRANSFER VM BALLANTINE, 1600A
MICROPOTENTIOMETERS BALLANTINE 440
RATIO TRANSFORMERS, GERTSCH
CALIBRATION CONSOLE 100Hz-100kHz FOR 0.25% ACCURACY INSTRUMENTS
LEVEL CHECK – DAILY
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 1 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH
CALIBRATION CONSOLES 2Hz-20MHz FOR 1%-3% ACCURACY INSTRUMENTS
LEVEL CHECK – 1 WEEK
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 3 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH
CROSSCHECK CONSOLE 2-20MHz FOR 1%-3% ACCURACY INSTRUMENTS
LEVEL CHECK – 1 WEEK
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 3 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH

Ballantine's Quality Assurance program satisfied the requirements of MIL-I-45208

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MODELS 323 and 323-01 TRUE RMS VOLTMETERS

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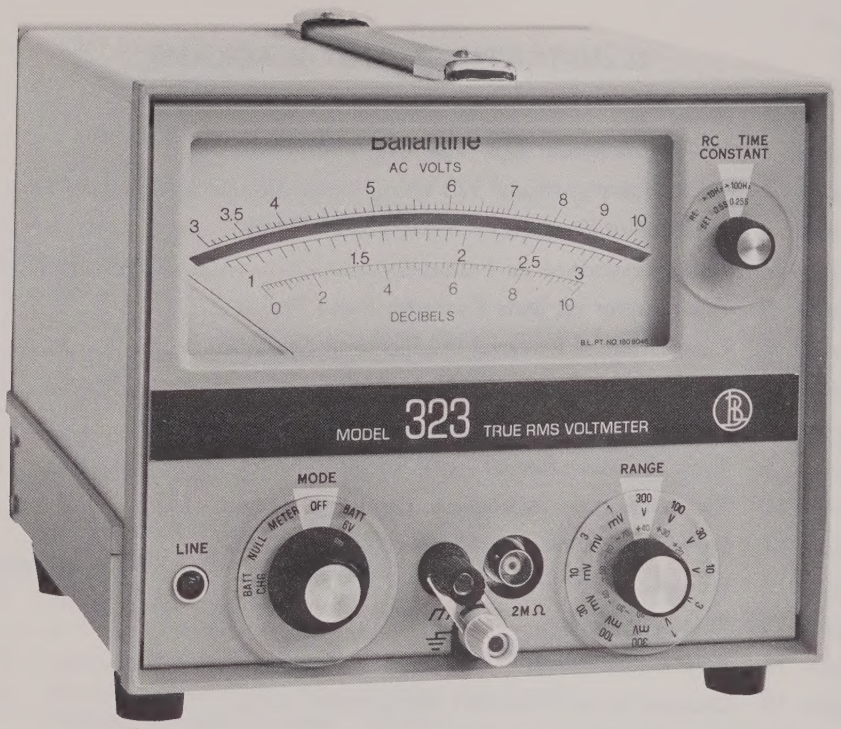


Fig. 1. Ballantine Model 323 True RMS Voltmeter

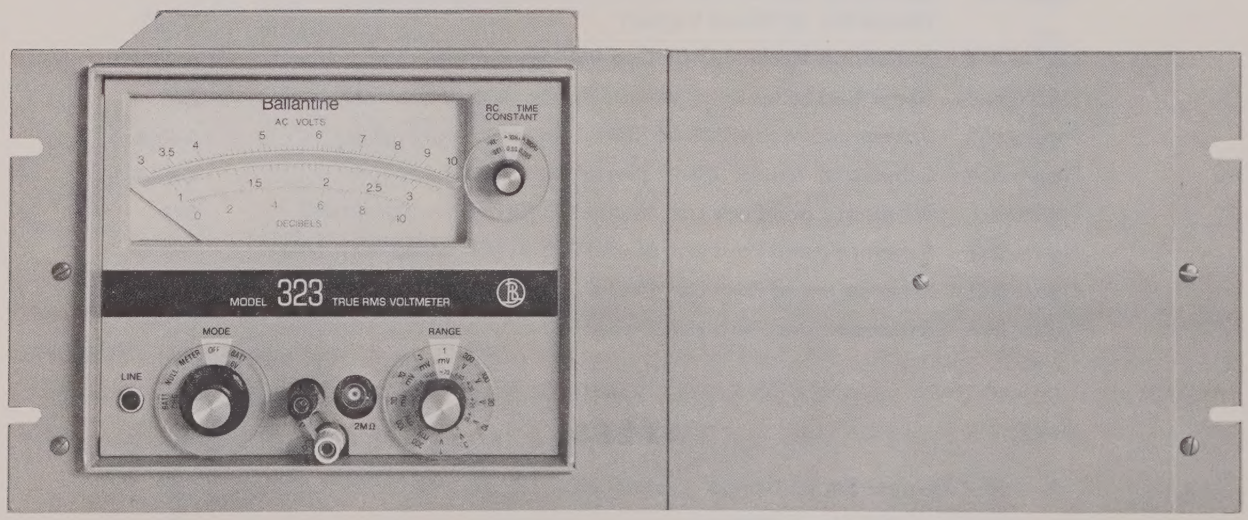


Fig. 2. Rack Mounted Model 323 Using Model 800 Rack Mounting Kit

1. GENERAL INFORMATION

Note: Unless otherwise noted, the information in this manual for the Models 323 and 323-01 of the 323 Series True RMS Voltmeters is also applicable to all other models of the 323 Series. Difference information is noted by reference to a specific model number or by the use of a triangular symbol (▶) adjacent to the text or an illustration or table title to indicate that the difference information is included in the addendum to this manual.

1.1 Features

The Ballantine Models 323 and 323-01 True RMS Voltmeters are compact, portable, general purpose ac voltmeters. The Model 323 operates from either line power or internal rechargeable batteries; the Model 323-01 operates from line power only.

Among the electrical features are high sensitivity, wide voltage range, wide frequency range, high accuracy, high input impedance, and high stability.

The signal-rectifier response is **true rms** and should not be confused with **average** or **peak** responding instruments calibrated to provide rms indication on sine waves only. Thus this instrument indicates the rms value on all types of waveforms which fall within its frequency and crest factor specifications.

The logarithmic meter provides the same high accuracy of indication at all points on the scale, while the associated linear decibel scale permits automatic conversion of voltage ratio to decibel units without recourse to charts or tables.

When desired, several time constants* may be selected by means of a front panel control.

For field operation, or when ground loops prove troublesome, the Model 323 may be operated from internal batteries for periods of up to 20 hours. An internal charging circuit completely recharges the batteries in a 15 hour period.

Three-terminal, unsymmetrical input permits grounding of the instrument case independent of the signal ground. Input circuit protection allows the maximum measurable voltage (330 V) to be applied to the most sensitive range at frequencies up to 1000 Hz with no damage.

A dc output, which is a squared function of the input voltage, is available at a rear mounted connector.

In the NULL mode of operation, signal voltages down to 70 μV are detectable.

With accessory shunt resistors (Ballantine Laboratories, Inc., Model 600 Series) the instrument may also be used as a sensitive accurate ac current indicator.

The use of solid-state active devices throughout leads to low power consumption, low internal temperature rise, stability and freedom from frequent recalibrations.

Mechanically the instrument is of simple, rugged design providing excellent accessibility to adjustments and components. The use of etched circuit boards and solid state components leads to compactness and light weight. An adjustable bail permits tilting of the instrument for better viewing. The half-rack modular case may be rack mounted in minutes by using the Model 800 Rack Mounting Kit.

1.2 Some Applications of the Models 323 & 323-01

General rms voltage and current measurements.

Noise measurements of tubes, transistors, and other components.

True-rms vibration measurements in conjunction with vibration pickup.

Noise tests of audio, video, and wide band systems.

Acoustic level and power measurements when used with suitable transducers.

Harmonic distortion measurements in conjunction with fundamental suppression filters.

1.3 Technical Characteristics

Model	Sensitivity		0 dB Reference			Frequency	
	Max. Fs		1 mW into			Lowest Specified	
	1 mV	300 μV	1000Ω	600Ω	75Ω	2 Hz	10 Hz
ac line + internal battery operation							
323	■		■				■
323L	■		■			■	■
323-06	■	■		■			■
323L-06	■	■		■		■	■
ac line operation only							
323-01	■		■				■
323L-01	■		■			■	■
323-07	■	■		■			■
323L-07	■	■		■		■	■
special purpose ac line + battery operation							
323-12[1]	■				■		■
323-20[1]	■	■	■				■
323L-20[2]	■	■	■			■	■

1. Same specifications as 323-06 except for 0dB scale reference.
2. Same specifications as 323L-06 except for 0dB scale reference.

NOTE: Models 323-20 and 323L-20 are available in a MOD40 configuration to meet severe environmental conditions.

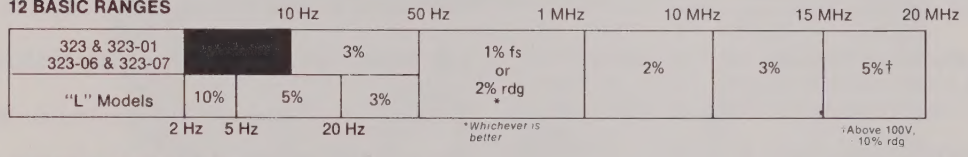
*Early production units had only one time constant of 0.4 s.

MODEL*					
ac line + internal battery operation	323	323L	323-06	323L-06
ac line operation only	323-01	323L-01	323-07	323L-07
Voltage Range	1 mV full scale to 300V full scale in twelve 10 dB steps		Same as 323, and additionally to 300μV full scale in METER +10 dB mode	
Calibration	True rms (effective heating value) of input waveform.			
Min.-Max. Scale Indication	300μV to 330V		100μV to 330V	
Decibel Range	−70 dB to +50 dB (0 dB = 1 mW/1000Ω)		−78 dBm to +52 dBm (0 dBm = 1 mW/600Ω)	
Frequency Range (12 basic ranges)	10 Hz to 20 MHz −3 dB ≈ 4 Hz Useable to ≈50 MHz	2 Hz to 20 MHz −3 dB ≈ 0.5 Hz	Same as 323	Same as 323L
Scale Calibrations	Log Voltage: 0.95-3.30 & 3.0-10.6 Linear dB: 0 to 10		Log Voltage: .095-.33 & .3-1.06 Linear dB: −8.2 to +2.6	

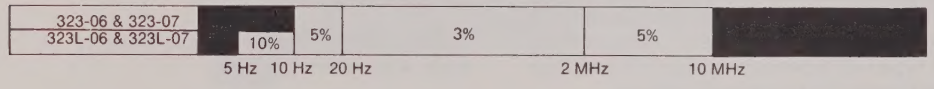
ACCURACY

In ± Percent of Reading (unless otherwise shown).

12 BASIC RANGES



"METER +10dB" RANGE



Input Terminal: BNC, floating or grounded with respect to chassis. Convertible to floating or grounded ¾-inch spaced banana jack binding posts with supplied Model 618 adapter.

Input Impedance: Signal High to Low, 2MΩ II 15pF, for ranges above 30mV; 2MΩ II 25pF, for ranges 30mV and below.

Signal Low to Case Ground, >100MΩ II 400pF, for ranges above 300μV.

Signal High to Case Ground, >100MΩ II 0pF when BNC used and shell driven as guard, for ranges above 300μV.

Common Mode Rejection Ratio: >120dB @ dc; >80dB @ 60 Hz. Maximum case to signal ground voltage 600V (dc + ac peak).

Crest Factor: 7 at full scale, increasing to 21 at ⅓ full scale, except as limited by maximum input.

AC to DC Converter Output: Negative 1V dc at full scale, to 0.1V at bottom scale any range. Accuracy ±1% full scale. Output available simultaneously with meter indications. Output proportional to mean square of input signal. Source resistance 1.67 kΩ. Rear panel BNC.

Noise: <30μV (input terminated with 50Ω).

Meter Response: "RC Time Constant" control at 0.25s: <1 second to full scale. 10 dB overload recovery time typically 2s. "RC Time Constant" control at 0.5s: <2 seconds to full scale.

Overvoltage Protection: 500V (dc + pk ac) all ranges to 1 KHz. Ranges above 30 mV, limited to 10^8 Volt - Hz. Ranges 30 mV and below, limited to 10^7 Volt - Hz.

Reference Conditions: 23° ± 2°C; 80% RH; Line 117V ± 2%; Line Frequency 50 to 420 Hz; warmup 1 hr.

Accuracy Stability:

Warmup time	Usable after 15 sec. <0.5% drift after 15 min.
Effect of ±12% line voltage	<0.2%
Effect of 5% line frequency	<0.2%
Effect of 18°C to 30°C temperature	Indications remain within specified accuracies
Effect of 10°C to 40°C temperature	Typically 1.5 times specified accuracy
Effect of 0°C to 55°C temperature	Typically 3 times specified accuracy

Environmental Characteristics:

	Temperature	Altitude
Operating:	0°C to 55°C	0 to 3 Km
Non-Operating:	-54°C to +75°C	0 to 15 Km
Humidity:	0 to 95% RH to +50°C	

Power: 323, 323-06, 323L, 323L-06, 323-12, 323-20, 323L-20: ac line, or internal rechargeable NiCd by front panel switch. 5W. Battery operation time 20 hrs. Changing time 16 hr.

323-01, 323-07, 323L-01, 323L-07: ac line only. 4W.

AC: 105 to 135/210 to 270V, 50 to 420 Hz.

Dimensions: H-155mm (6.1") x W-198mm (7.8") x D-259mm (10.2").

Weight: Net: 3.4 Kg (7.5 lbs); with battery 4.3 Kg (9.5 lbs.).

Shipping: Gross: 5.4 Kg (12 lbs.); with battery 6.3 Kg (14 lbs.).

2. OPERATION

2.1 Function of Controls (See Fig. 3)

MODE Switch, 323

BATT 6 V	Provides battery check; when meter indication is less than 6 on upper meter scale, batteries should be recharged.
OFF	Turns power off.
METER	Instrument operates as voltmeter from power line or internal batteries, with dc output proportional to square of signal level available at DC OUT connector.
NULL	Instrument operates as a sensitive ac null indicator with maximum sensitivity of 70 μV; calibration is not accurate, merely relative.
BATT CHG	When connected to line, instrument fully charges batteries in 15 hour period; instrument is inoperative in this position.

MODE Switch, 323-01

OFF	Turns power off.
METER	Instrument operates as voltmeter with dc output proportional to square of signal level available at DC OUT connector.
NULL	Instrument operates as a sensitive ac null indicator with maximum sensitivity of 70 μV; calibration is not accurate, merely relative.

RANGE Switch Selects voltage range.

RC TIME CONSTANT

Switch	Selects detector time constant.
> 100 Hz* 0.25 s	Provides time constant of 0.25 s, to be used for frequencies above 100 Hz.
> 10 Hz 0.5 s	Provides time constant of 0.5 s, to be used for frequencies above 10 Hz.
RESET	Provides for rapid discharge of time constant capacitors, to "erase" indications when long time constants are used or following input overloads.
LINE	Pilot lamp indicating when instrument is connected to power line.

*Early production units had only one time constant, 0.4 s, marked NORMAL.

2.2 Connectors

Input

BNC	Coaxial signal input, may be converted to binding post with Ballantine Model 618 Adaptor supplied.
Black Binding Post	Connector for signal ground
White Binding Post	Connector for case ground.
DC OUT	BNC connector located on rear of instrument; low side is connected to signal ground.

2.3 Power Connection

The voltmeter is supplied ready to operate on either 105 V to 135 V or 210 V to 270 V, 50 Hz to 420 Hz power, as indicated on the decal located on the back of the case adjacent to the power cord.

2.3.1 Line Voltage Conversion

To change the operating line voltage of this instrument, proceed as follows:

A. Remove instrument cover

B. Locate line voltage switch at lower left hand corner of the rear panel (while facing the front of the instrument).

C. Move the switch to its upper position for 120 V operation, to the lower position for 240 V operation.

D. If the voltage chosen in step C does not agree with that on the decal located on the rear cover, revise the decal marking to avoid damage or malfunction.

E. Install a fuse consistent with the line voltage, chosen as follows:

Line	323	323-01
120 V	1/10 A, Slo-Blo	1/16 A, Slo-Blo
240 V	1/16 A, Slo-Blo	1/32 A, Slo-Blo

2.4 Starting Procedure

2.4.1 Line Operation

Insert the power plug into a source conforming with the requirements stated on the decal located on the rear panel. Set the MODE switch

Fig. 3. Location of Controls — Models 323, 323-01

to METER or NULL as desired. The LINE pilot lamp should glow.

2.4.2 Battery Operation, Battery Charge, 323 Only

Check the batteries by setting the MODE switch to BATT 6 V; the meter must indicate 6 or greater on the upper scale. If the indication is under 6 the batteries must first be recharged (see below). NOTE: On battery operation the LINE pilot lamp will not glow.

If the indication is 6 or greater, set the MODE switch to METER or NULL as desired.

To recharge the batteries, connect the power cord to a source conforming with the requirement stated on the decal located on the rear of the instrument. Rotate the MODE switch to BATT CHG. The batteries will be brought to a full charge after 15 hours; longer periods of charging (up to several weeks) are permissible and do no harm.

While the instrument is line operated, the batteries are continuously being charged at a rate equal to approximately one-half that of the BATT CHG position. Thus in an instrument which is continuously line operated for a period of 30 hours or more the batteries will be at or near full charge. It is recommended, however, that when 20 hours continuous use is necessary the batteries be charged on the BATT CHG position for 15 hours prior to use.

2.4.3 Warmup Period

The instrument is usable after approximately 15 seconds. After 15 minutes of operation the drift will be less than 0.5%.

When the instrument has not been in operation for many months, or when it has been stored in an area of high humidity, or when the meter indication is less than 6 with MODE switch at BATT 6 V, allow a warmup period of at least one hour.

The power dissipated in this instrument is small and leads to little temperature rise. Therefore no particular air circulation is needed for proper operation.

2.5 Measurement of AC Voltage

Set	To
MODE Switch	METER
RANGE Switch	300 V
RC TIME CONSTANT	0.5 s, or 0.25 s

Connect the unknown voltage to the input and rotate the RANGE switch until an on-scale indication is obtained. The position of the RANGE switch together with the meter indication gives the voltage at the input.

2.6 Possible Error Sources

Some of the more common sources of error in voltage measurements are listed below.

2.6.1 Pointer Stays Extreme Left

a. RANGE switch incorrectly set.

b. MODE switch incorrectly set.

c. RC TIME CONSTANT switch incorrectly set.

d. Input voltage lower than 300 μV (70 μV on NULL).

e. Input voltage or frequency above or below range of the instrument.

f. Defective power cord, fuse, or line voltage switch set to wrong position.

2.6.2 Pointer Stays Extreme Right

a. RANGE switch incorrectly set.

b. MODE switch on NULL rather than METER.

c. Input leads exposed to high electrostatic and/or magnetic field.

d. Input voltage greater than 330 V rms.

e Instrument not fully recovered from severe overload; set RC TIME CONSTANT switch to RESET to accelerate recovery.

Because of the wide frequency range and high sensitivity of the Model 323, measuring errors not noted on less sensitive, narrow-band instruments may be encountered. In most instances proper measurement techniques can either eliminate or reduce to negligible proportions errors of this nature. The most common of these are listed below A more comprehensi e analysis is contained in an NBS Conference on Standards and Electronic Measurements Paper entitled, "Techniques and Error n High Frequency Voltage Calibration" by D E Uiga and W. F. White A copy of this paper is available from Ballantine Laboratories without charge.

2.6.3 Loading Error, Input Characteristics

The input impedance of this instrument may be represented as a delta configuration of three resistances and capacitances (See Fig. 4). The low frequency value of these resistances and capacitances is given in Table I. While the capacitances are essentially independent of frequency, the value of RA is not, and is shown in Fig. 4.

Table I — Input Parameters vs Range

Ranges	RA	RB	RC	CA	CB	CC
1 mV - 30 mV	2 MΩ	> 100 MΩ	> 100 MΩ	25 pF	≅ 400 pF	≅ 0 pF*
100 mV - 300 V	2 MΩ	> 100 MΩ	> 100 MΩ	15 pF	≅ 400 pF	≅ 0 pF*

*With BNC input connector

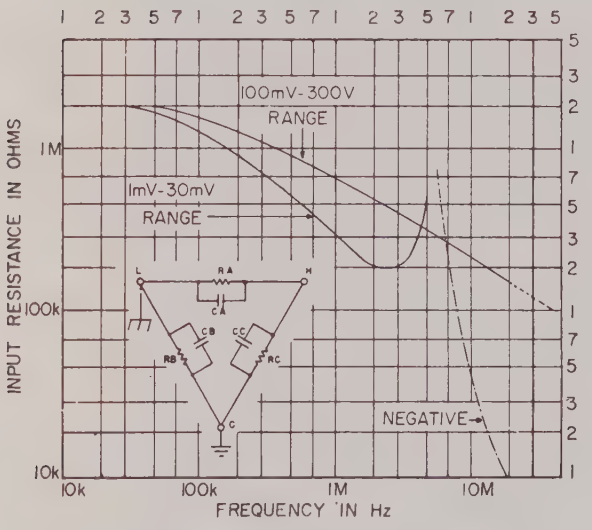


Fig. 4. Input Resistance vs. Frequency

It should be noted that RA becomes negative at higher frequencies on the four most sensitive ranges. If a circuit or inductor resonant in this region is connected across the input terminals (H, L) oscillation may result. This can be eliminated by connecting a resistance across the input terminals equal to or lower than the negative resistance. At lower frequencies on these ranges, and at all frequencies on the other ranges, the effect of the input impedance is to load and/or detune the source; this should be considered when the source impedance is high or is a tuned circuit.

2.6.4 Ground Current Errors

A common source of error in low level measurements is ground current, i.e. a current of signal, power, or other frequency flowing in a ground lead impedance. This results in a voltage in addition to the desired signal voltage appearing at the input terminals. The effect of such a current may be eliminated or reduced by:

a. Eliminating or reducing the ground current where possible. Isolation transformers (low capacitance, high resistance) in power line leads are effective in breaking power and other low frequency ground current loops.

b. Employing coaxial signal leads and keeping these as short and direct as possible.

c. Making all known ground impedance as low as possible.

d. Operating the Model 323 on battery.

2.6.5 Transmission Line Error

At higher frequencies and with long lengths of connecting coax, errors caused by standing waves in unmatched systems may result. This is most easily dealt with by employing a matched system.

2.6.6 Magnetic and/or Electrostatic Field Error

Strong electrostatic and/or magnetic fields close to signal leads or the voltmeter itself can give rise to errors, particularly at the higher frequencies. Shielding and distance can be effectively employed to reduce or eliminate errors of this nature.

2.7 Use of the DB Scale

The dB scale on the Model 323 is referenced to 1 on the voltage scale. If 1 V is selected as a zero reference, measurements from +50 dB to −70 dB may be made. Each step of the range knob either adds or subtracts 10 dB from a selected level.

To help compute and convert dB levels from one reference to another, a dB slide rule is available from Ballantine Laboratories.

2.8 Effect of Harmonics

With complex waveforms this instrument measures the true rms value independent of the phase relationship of the harmonics, provided that all the harmonics fall within the frequency range of the instrument. The error caused by harmonics falling outside the calibrated range of the instrument is a function of both the relative energy contained in these harmonics as well as the relative response of the voltmeter in this area. Although the instrument is calibrated from 10 Hz to 20 MHz the response extends beyond these frequencies. It is down 3 dB at approximately 4 Hz and 30 MHz. To compute the rms value of a voltage when the rms magnitudes of its components are known, equation 1 may be used.

$$E_{RMS} = (E_1^2 + E_2^2 + E_3^2 \ldots E_N^2)^{1/2} \quad (1)$$

E_{RMS} rms amplitude of the complex waveform

$E_{1 \ldots N}$ rms amplitude of harmonic

2.9 Effect of Crest Factor

The instrument has a crest factor (ratio of peak to rms amplitude) capability of 5 at full scale, increasing proportionately to 15 down scale. Crest factors greater than this cause errors because of detector response and/or amplifier overloading.

2.9.1 Flat-Topped Waveforms

Specified accuracy is maintained for flat-topped waveforms providing the crest factor and bandwidth specifications are not exceeded. Fig. 5 is a curve showing the relationship of crest factor to duty cycle for pulse trains.

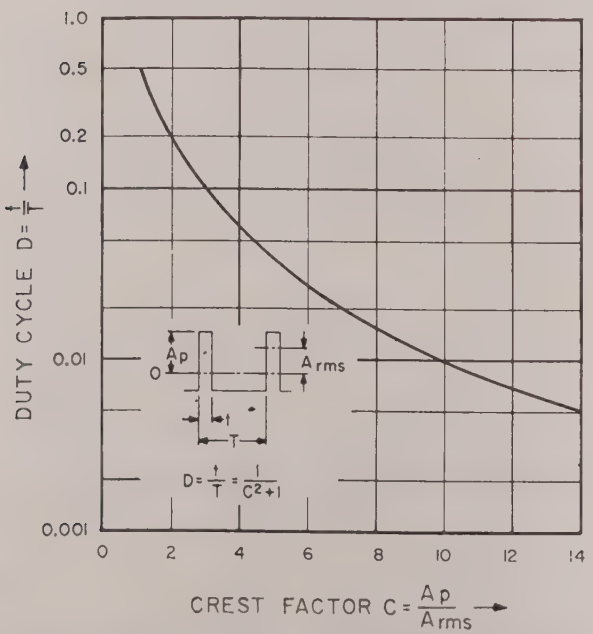


Fig. 5. Crest Factor vs. Duty Cycle for Pulse Trains

2.10 Effect of DC Component

This instrument responds only to the ac component of a waveform. If it is desired to include the dc component present in a waveform, this component should be measured separately with a dc voltmeter.

The true rms value may now be computed from:

$$E_{RMS} = (E_{dc}^2 + E_{ac}^2)^{1/2} \quad (2)$$

Example:

1 V dc is chopped into square pulses with 1 V peak amplitude. This pulse train has a dc component of 0.5 V which may be measured with a dc voltmeter. The ac component of this waveform will be 0.5 V rms when measured with the Model 323, 323-01. The total rms value is

$$E_{RMS} = (E_{dc}^2 + E_{ac}^2)^{1/2} = (0.5^2 + 0.5^2)^{1/2} = 0.707\ V$$

The dc component of waveform is blocked by an input capacitor which has a 600 V dc maximum rating. When a dc component exceeding 600 V is present, an external blocking capacitor with a suitable dc rating should be connected as in Fig. 6. The value of this capacitor should be at least 0.1 μF if it is desired to measure to the lowest specified frequency (10 Hz).

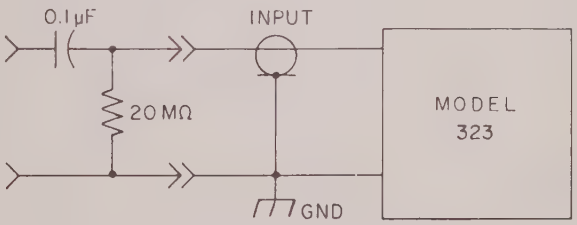


Fig. 6. Connection of External DC Blocking Capacitor

2.11 Measurement of Noise, Random Signals

When noise or random signals are measured an error which is a function of bandwidth and crest factor limitations may be introduced. The rms value of "white" noise is given by

$$E_{rms} = (4KRT\triangle F)^{1/2} \quad (3)$$

where

K = Boltzmann's constant = 1.374×10^{-23}

R = source resistance

T = temperature in ° Kelvin

$\triangle F$ = bandwidth in Hz

For wideband noise measurement the bandwidth of this instrument may be taken as 30 MHz. For measurement of noise sources with a bandwidth greater than 30 MHz, equation (3) may be used to calculate the error introduced by bandwidth limitation. Crest factor limitations introduce an error when measuring noise or random occurrences with Gaussian amplitude distribution. This error is depicted

in Fig. 7. The crest factor limit of 5 at full scale introduces an error of less than 0.01% which is negligible. If an element (such as a preamplifier) having a lower crest factor capability is used ahead of the instrument, it may be necessary to consider this source of error.

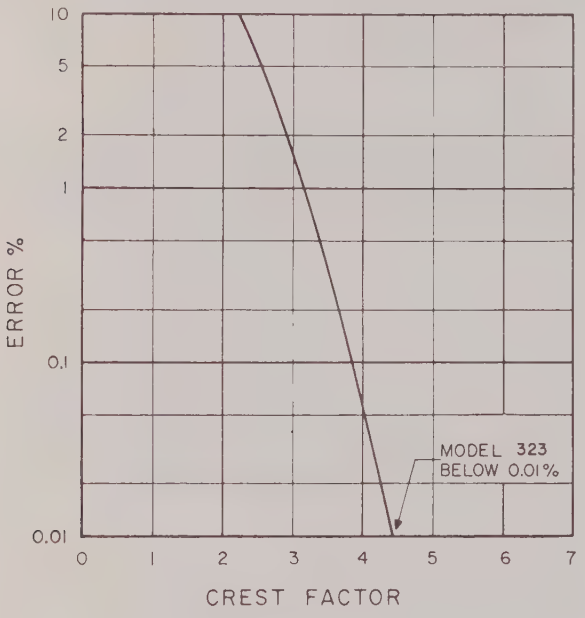


Fig. 7. Crest Factor Error with White Noise

2.12 Measurement of Waveforms with Crest Factor Greater than 5

While the crest factor limit is 5 at full scale, crest factors greater than this are permissible at lower scale indications. See Equation 4.

$$CF = \frac{5}{K} \qquad (4)$$

where K = fraction of full scale indication.

Thus at half scale or below, waveforms with a crest factor of 10 may be measured. Fig. 8 shows an external 2:1 attenuator which may be used to bring indications to the lower half of the scale, permitting waveforms with crest factors as high as 10 to be measured. With indications which would normally fall on the upper portion of the scale, the switch is set to X2 and the indication multiplied by 2.

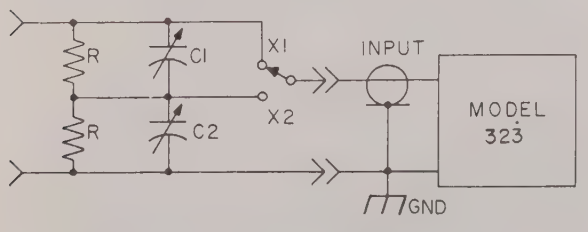


Fig. 8. External Attenuator to Extend Crest Factor Limit

The resistors R should be matched to 0.1%, and capacitor C1 should be adjusted (while connected to the voltmeter) for an accurate 2:1 attenuation at the highest frequency of interest.

At very low frequencies where all the harmonic components fall within its range, a ratio transformer may be used.

2.13 Use as Null Detector

When the signal voltage applied to the input terminals falls below 300 μV, measurements in the METER mode are no longer possible since the meter indication falls below the lowest calibrated point on the scale.

Setting the MODE switch to NULL brings the meter indicator up in the absence of any signal, making possible null indications down to approximately 70 μV. In this mode of operation considerable indicator fluctuation is normal and does not indicate malfunction of the instrument. A curve typical of the indication vs input voltage in the NULL mode is shown in Fig. 9.

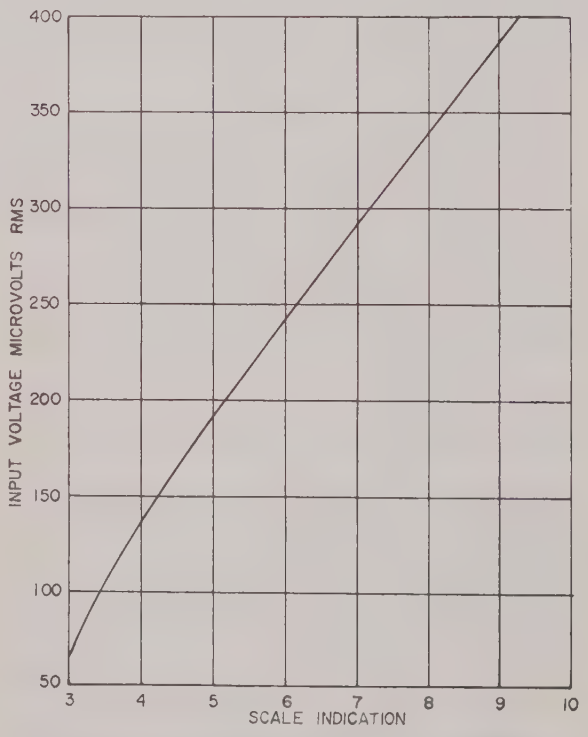


Fig. 9. Typical Calibration of 1 mV Range in NULL Mode

2.14 Measurements Below 300 μV

By setting the MODE switch to NULL, approximate measurements below 300 μV become possible. Fig. 9 is a curve showing the typical relationship between

the indication and the signal level at the input terminals.

2.15 Measurements Above 330 V

Voltages up to 10 kV rms may be measured by using the Ballantine Model 1301 (binding post termination) or Model 1311 (coaxial termination) High Voltage Probe in conjunction with the Model 323, 323-01. This probe is an accurate 10,000:1 (80 dB) attenuator, and presents an input impedance of 4.5 pF in parallel with 10,000 MΩ minimum. The frequency range of the probe is 30 Hz to 1 MHz when used with the Model 323, 323-01. The additional error introduced by the probe is 1% or less.

2.16 Overload Protection

The instrument is fully protected against overloads up to 330 V* input on any range at frequencies up to 1 kHz. At frequencies above this the maximum input voltage on the 1 mV through 30 mV ranges (4 ranges) must not be greater than

$$E_{max} = 33 \text{ mV or } \frac{330 \text{ V}}{f_2} \quad \text{whichever is greater} \quad (5)$$

where f_2 is in kHz. See Table II.

Table II — Maximum Safe Input Voltage

Ranges	$f_2 < 1$ kHz	$f_2 > 1$ kHz
1 mV - 30 mV	330 V*	33 mV or $\frac{330 \text{ V}}{f_2 \text{ in kHz}}$ whichever is greater
100 mV - 300 V	330 V*	330 V

Equation 5 assumes that the signal source impedance is zero or very low, which is almost never the case at these frequencies. It will be found that in general no precautions need be taken about overloads providing the input voltage does not exceed 330 V.

*500 V peak

2.17 Influence of Power Line Voltage

Model 323

Operation on line voltages of 105 V to 135 V (210 V to 270 V) causes no discernible change in indications on the Model 323, providing the battery is properly charged. See Section 2.4.2.

Model 323-01

Operation on line voltages of 105 V to 135 V (210 V to 270 V) causes no discernible change in indications on the Model 323-01.

2.18 Influence of Battery Voltage, 323 Only

The battery employed in this instrument is a nickel-cadmium rechargeable type, affording 20 hours continuous operation from a fully charged condition. A curve of voltage vs discharge is shown in Fig. 10.

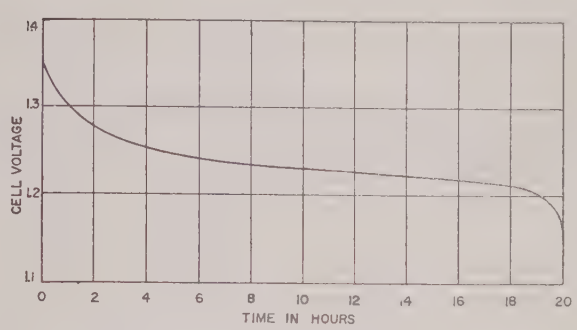


Fig. 10. Typical Battery Voltage vs. Discharge Time

It will be noted that over most of the discharge period the battery voltage is essentially constant. Near the very end of the discharge time the voltage begins to fall rapidly. Over the "flat" portion of battery discharge the Model 323 will meet all specifications; near the very end an additional error of up to −1% may be encountered.

2.19 Influence of Ambient Temperature

The instrument accuracies (See Section 1.3 Technical Characteristics) apply over the ambient temperature range of 18°C to 30°C. For ambient temperatures in the region of 10°C to 40°C an additional uncertainty of one-half the stated accuracy may be incurred.

The above assumes that the instrument has been allowed to stabilize for a period and is not subject to temperature gradients or drafts.

2.20 Measurement of RMS Current

The voltage drop caused by a current flowing through a resistor can be measured with the Model 323, 323-01, and the rms value of the current computed. The Ballantine Model 600 series of precision wirewound resistors are designed for this purpose and are available in decade ranges from 0.01 Ω to 1000 Ω. The range of current with these resistors is 300 nA to 10 A. The crest factor is the same as for voltage measurements, while the frequency range is dependent upon the resistor used. The 0.01 Ω resistor is suitable for RMS current measurements to 20 kHz, the 1000 Ω resistor is good to 200 kHz.

2.21 Measurement of Power

The power dissipated in a pure resistive load may be measured with the Model 323, 323-01 from the formula

$$P = \frac{E^2}{R} \qquad (6)$$

Power ratios are frequently expressed in decibels (dB) obtained from

$$PR\ (dB) = 10 \log_{10} \frac{P_2}{P_1} \qquad (7)$$

When the resistance across which P_2 and P_1 are developed is the same

$$PR\ (dB) = 10 \log_{10} \frac{\frac{E_2^2}{R}}{\frac{E_1^2}{R}} = 20 \log_{10} \frac{E_2}{E_1} \qquad (8)$$

Thus the decibel scale on the Model 323, 323-01 may be used to measure power ratios directly across a common resistance, or equal resistances. The 0 on the decibel scale is referenced to 1 on the voltage scale; other voltage references are available on special order.

2.22 DC Output

A dc voltage, which is a squared function of the ac input voltage, is available on each voltage range at a rear mounted BNC connector. The "low" terminal is at signal ground potential and may be tied to systems ground as desired. The amplitude is −1 V, ±1% for a meter indication of 10 V, with a linearity error not exceeding ±0.3% of full scale. The source resistance is approximately 1667 ohms. The load resistance may be as low as zero Ω in which case a current of 600 μA, ±3% will be delivered.

The time constant associated with this dc output is 0.25 s or 0.5 s, selectable by the RC TIME CONSTANT switch on the front panel. Other time constants are available or may be added to the instrument. See Sections 2.23, 5.12 and Table III.

The ripple voltage at 1 kHz is < 1.5% increasing to < 4.0% at 10 Hz, with the 0.5 s TIME CONSTANT.

Table III — Capacitance vs Time Constant

Time Constant Seconds	Capacitance Calculated Value	Capacitors Standard Value
1.0	4.76 μF	5.0 μF
2.0	9.53 μF	10.0 μF
3.0	14.4 μF	15.0 μF
5.0	23.8 μF	22.0 μF
7.0	33.3 μF	33.0 μF
10.0	47.6 μF	47.0 μF
20.0	95.3 μF	100.0 μF
30.0	144.0 μF	150.0 μF

CAUTION

Damage to the signal rectifiers, meter movement or both may result if a source of voltage or current (dc or ac) is connected to the dc output connector.

If in an application there is any doubt, the external device should be checked with both a sensitive ac and dc voltmeter.

2.23 RC Time Constant, Reset, Response Time

The rc time constant in this instrument refers specifically to the DC OUT (See Section 2.22) and somewhat less specifically to the meter indication, since the meter movement electromechanically introduces a square root function. The two are not independent of each other, and are determined for the most part by the same circuit elements (meter ballistics enter the situation with fast time constants). The dominant time constant for all but very short ones is determined by the rc filter at the output of the rms detector.

The instrument is supplied with two time constants, 0.25 s* and 0.5 s, selectable by the RC TIME CONSTANT switch. The faster 0.25 s is for frequencies above 100 Hz; below this frequency there will be considerable error and needle flutter. The 0.5 s time constant is usable from 10 Hz upward. Other time constants (up to 30 s) are available on special order or may be added by the user. See Section 5.12 and Table III.

The response time (meter indication or DC OUT) is directly related to the time constant, i.e. the longer the time constant, the longer the response time. It takes approximately 4.5 time constants to achieve 99% of the final indication or DC OUT. Thus on the 0.5 s time constant the response time (for 99% of final) would be approximately 2 s.

When this instrument is subjected to severe input overloads while employing long rc time constants, the recovery time may be excessive. The crest factor capabilities of the wideband amplifier and rms detector make it possible to charge up the capacitors

*Early production units incorporated only one time constant 0.4 s, which was labelled NORMAL.

in the rc filter far beyond normal levels on input overloads; the capacitors must then discharge to normal levels. To speed up this discharge, shorting positions have been incorporated on the RC TIME CONSTANT switch and are designated RESET. Actually it is necessary only to advance this switch one position clockwise to discharge the capacitors in use. It should be noted that the use of the RESET does not fully discharge the capacitors; a property of all capacitors called "dielectric absorption" prevents their giving up all their energy in zero time.

2.24 Indicator Flutter, Beats at Lower Frequencies

There are two sources of indicator flutter or beating in this instrument at the lower frequencies. Both are related to filtering following the rms detector. One, however, is also a function of the chopper frequency, while the other is not.

The first source of flutter is the ac ripple present on the dc output from the rms detector and its filter. This ripple is inversely related to frequency and may be reduced by increasing the rc time constant in the rms detector output. See Sections 2.23, 5.12. However, increases in time constant also result in increases in response and overload recovery time.

A second source of indicator fluctuation is beating between ripple components in the rms detector filter output and the chopper frequency (94 Hz). These beats (as opposed to flutter) will be noted with signals at or near the chopper frequency, its subharmonics, and to a lesser extent, its harmonics. Again the fluctuation may be reduced or eliminated by increasing the rc time constant, with attendant increases in response time and overload recovery. See Sections 2.23, 5.12.

3. CIRCUIT DESCRIPTION

3.1 Basic Circuitry

The basic circuitry of this instrument is shown in Fig. 11, Simplified Schematic, while a complete schematic, Figs. 18, 19, is located at the end of the manual.

Tracing the signal, the ac input is attenuated as necessary, amplified in the wideband amplifier, attenuated again as necessary, converted to dc in the rms detector, converted to 94 Hz ac by means of a mechanical modulator, amplified further in the 94 Hz amplifier, demodulated, passed through a meter to provide indication, and through a resistor to provide a dc output.

Since the basic sensitivity of the instrument is 1 mV full scale, it is necessary either to change this sensitivity or to use attenuators for higher level signals. A pair of attenuators is used and Table IV is a schedule of attenuation vs range setting.

Table IV — Attenuation vs Range Switch

Range	Input Attenuation	Output Attenuation	Total Attenuation
1 mV	0 dB	0 dB	0 dB
3 mV	0 dB	10 dB	10 dB
10 mV	0 dB	20 dB	20 dB
30 mV	0 dB	30 dB	30 dB
100 mV	40 dB	0 dB	40 dB
300 mV	40 dB	10 dB	50 dB
1 V	40 dB	20 dB	60 dB
3 V	40 dB	30 dB	70 dB
10 V	80 dB	0 dB	80 dB
30 V	80 dB	10 dB	90 dB
100 V	80 dB	20 dB	100 dB
300 V	80 dB	30 dB	110 dB

The following sections discuss in some detail the basic units, their circuitry and, in some instances, components used.

3.2 Input Attenuator

The input attenuator provides attenuation of 0, 40, and 80 dB and is of the resistance-capacitance type. At low frequencies the attenuation-ratio is determined entirely by the resistors, at high frequencies by the capacitors. The crossover from resistive to capacitive attenuator occurs at approximately 25 kHz.

The resistors used are high-stability, metal-film units initially matched to 0.1 %. The capacitors use polystyrene (adjustable) and mica (fixed) as dielectrics, which afford high stability and excellent high frequency characteristics.

3.3 Input Protection

A set of four diodes connected in series parallel across the input of the wideband amplifier limit the voltage to the input device to approximately ±1.8 V maximum. The series reactance of the input capacitor and a small series resistor limit the diode current to safe values at frequencies below 1 kHz with 330 V applied to the input. In general, at frequencies higher than 1 kHz the generator or source resistance also serves to limit the current flow to a safe value.

It should be noted that the protective circuit is necessary primarily on the four most sensitive ranges. On all higher ranges the input attenuator reduces the input voltage to a safe value provided that no more than 330 V is applied to the input terminals.

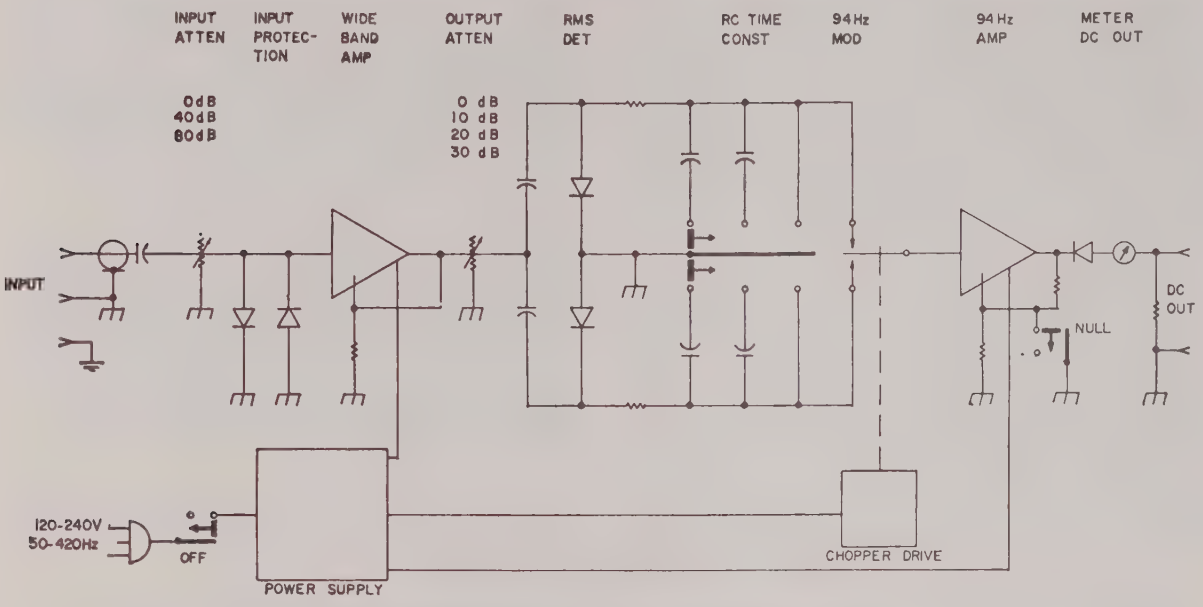


Fig. 11. Simplified Schematic, Models 323, 323-01

3.4 Wideband Amplifier

The wideband amplifier provides a voltage gain of approximately 6 over the frequency range of 10 Hz to > 20 MHz. Although the voltage gain is rather modest the power gain is large because of the great disparity in input and output resistance. The output voltage of the amplifier is developed across the output attenuator which has an impedance of approximately 200 Ω.

3.5 Output Attenuator

The output attenuator provides attenuation of 0, 10, 20 and 30 dB and is of the ladder variety. The attenuator is essentially resistive over the entire frequency range; capacitance trimming is used to correct small departures at the highest frequencies on some positions.

Metal film resistors, initially matched to 0.1 %, and ceramic capacitors are used.

The output of the attenuator goes to the rms detector.

3.6 RMS Detector

The rms detector converts the ac signal over a frequency range of 10 Hz to 20 MHz and over an amplitude range of 10 dB (approximately 1.9 mV to 6 mV) to a balanced dc signal with a corresponding amplitude range of 20 dB (approximately 50 μV to 500 μV). A dual section rc filter is employed as an integrating and averaging device. A switch in this circuit permits a choice of rc time constants as well as a shorting position (RESET) to help remove capacitor charge following overloads.

The detector diodes are of the silicon Uni-Tunnel or "backward" type. By operating these units at a low level (near the origin on V, I curve) a nearly perfect square law relationship between the input ac and output dc is obtained. Moreover the dynamic range of the "square-law" region can be made large enough to permit relatively large crest factors (at least 5:1).

The output of the rms detector goes to the 94 Hz modulator.

3.7 94 Hz Modulator

The 94 Hz modulator converts the balanced dc signal from the rms detector to a 94 Hz square wave, and passes it on to the 94 Hz amplifier.

An electromechanical modulator (chopper) is used since, of the various types available, it displays:

1. Highest conversion efficiency
2. Lowest residual noise level
3. Lowest residual dc
4. Lowest dc drift

To avoid dependence on power supply frequency and to reduce the effects of power supply hum, the chopper operates at a frequency of 94 Hz. Thus the power supply frequency is limited only by other considerations (transformer, ripple, etc.) and may be any of the common supply frequencies between 50 and 420 Hz.

3.8 94 Hz Amplifier

The low level ac signal (94 Hz) from the modulator is amplified by the 94 Hz amplifier to a level suitable for driving an indicator. This amplifier, while not sharply tuned, does fall off at frequencies above and below 94 Hz, thereby reducing undesirable low and high frequency noise.

The amplifier uses silicon junction transistors in a three stage circuit. The first two transistors are direct coupled and operated at very low current to provide high input impedance and low noise. In the output stage one of the two transistors is operated in grounded base configuration to provide a high collector impedance for the other unit. Overall ac feedback is employed to stabilize the gain against component changes, environmental effects, etc. In the NULL mode of operation the feedback is removed to provide greater sensitivity. There is an attendant loss of stability, increase in noise, etc.

3.9 Rectifier, Meter, DC Output

AC signal current from the 94 Hz amplifier is rectified by a pair of diodes to provide dc current for the meter; this current is also passed through a resistor to provide a dc output. A capacitor across the meter and dc load reduces pointer fluctuation and ripple. Because of the high drive impedance, shorting the dc output has little or no effect on meter indications.

The signal diodes are hermetically sealed silicon units virtually immune to aging and environmental effect. The meter has a taut-band suspension and employs shaped pole pieces to achieve a logarithmic characteristic.

3.10 Chopper Drive

The chopper drive employs 4 silicon transistors to convert 6 V dc to a 94 Hz square wave. Two of the transistors, operating as a multivibrator, drive the other two transistors as switches.

3.11 Power Supply, Model 323

The power supply uses a line transformer and full-wave bridge rectifier to provide dc current for battery charging. The current is regulated to the proper charging rate (120 mA) by a solid state regulator employing a zener diode and transistor. The 12 V nickel-cadmium battery provides operating potentials for both amplifiers; a 6 V tap provides potential to the chopper drive circuit. THIS BATTERY IS NECESSARY TO THE OPERATION OF THE INSTRUMENT EVEN WHEN ON LINE POWER. NO ATTEMPT SHOULD BE MADE TO OPERATE WITHOUT BATTERIES.

3.12 Power Supply, Model 323-01

This power supply uses a line transformer and full-wave bridge rectifier to supply dc operating potentials for the amplifiers and chopper drive circuit. A zener diode is used to stabilize the voltage for chopper drive, while a pair of zeners ad a transistor are used to regulate the supply voltage to the amplifiers.

4. MAINTENANCE

4.1 General

The Model 323, 323-01 has been designed for extended, trouble-free operation, and should seldom require servicing or maintenance. The design employs all silicon devices except for one germanium transistor (323 only) in the power supply, and all components are operated well below their maximum ratings. Checks at Ballantine Laboratories, Inc. indicate that at least several thousand hours of operation can be expected before there is any need for recalibration.

The purpose of this section is to provide procedures for checking performance and correcting if necessary. The Periodic Checks (Section 4.4) not only check performance, but may also help detect incipient failure and assure instrument accuracy until the next periodic check.

4.2 Equipment Required

A. Stable, accurately-calibrated ac voltage source, with a voltage range of at least 500 μV to 100 V rms, and at a frequency of 400 Hz to 1 kHz. The Ballantine Model 421A is recommended.

B. An accurate, high impedance dc voltmeter covering a range of at least 100 mV to 1 V. The Ballantine Model 365 is recommended.

C. An accurate, high impedance ac voltmeter covering a range of at least 5 to 10 V. The Ballantine Model 300G, 300H, 302C, 303, 310B, 320A and 323 are recommended.

4.3 Recommended Checks

It is recommended that the checks outlined in Section 4 be made every 2,000 hours of operation, or once a year. If the instrument is stored or operated under severe environmental conditions the frequency of these checks should be increased to a rate consistent with these conditions.

4.4 Checks

4.4.1 Amplifier Level and Scale Adjustments

To make the amplifier dc level and scale adments, proceed as follows:

A. Connect a dc voltmeter from ground to C53+. Adjust R71, the AMP DC LEV adjustment, for a reading of approximately +4.9 to +5.1 volts.

B. Connect a stable signal of 400 Hz-1 kHz to the input and adjust for an indication of precisely 10 on the 1 V range.

C. Reduce the signal level by precisely 0.3162 (10 dB) and note the scale indication. If the meter does not indicate 3.162

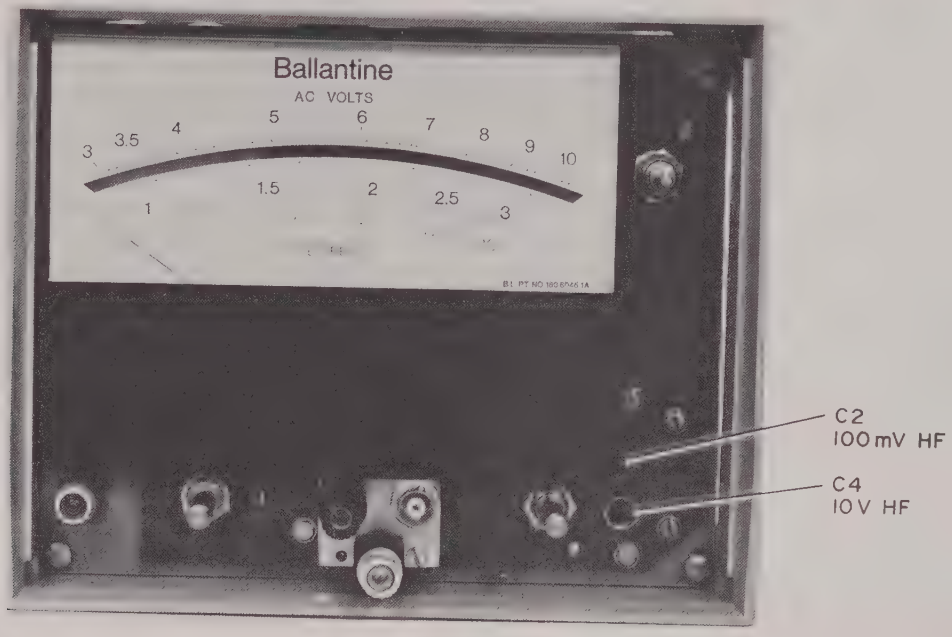


Fig. 12. Front Adjustments

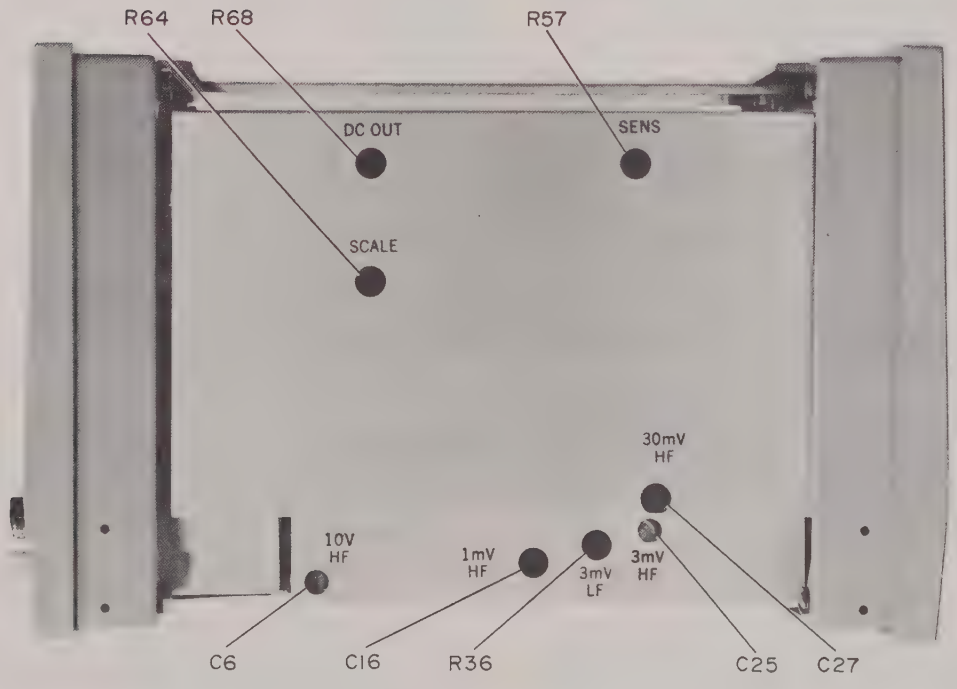


Fig. 13. Side Adjustments

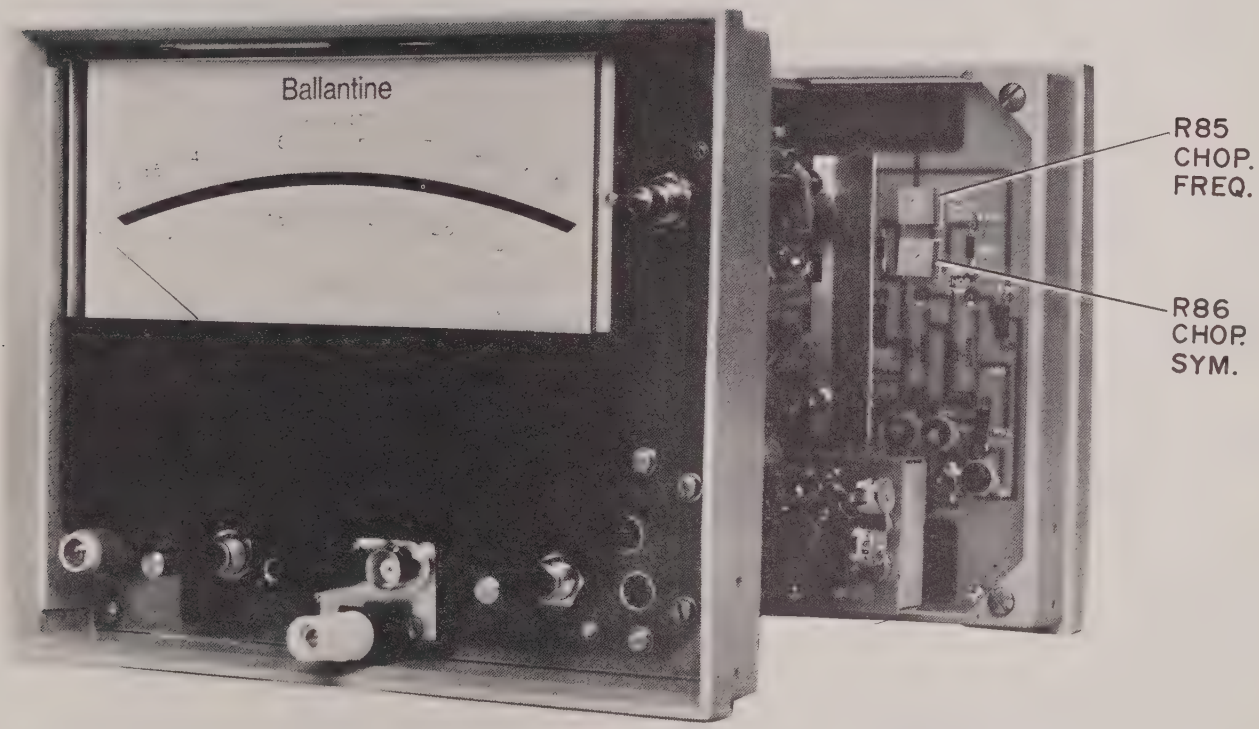


Fig. 14. Rear Adjustments

(1 on the lower scale), adjust the SCALE adjustment (see Fig. 13) for this indication.

D. If necessary, readjust R71. Repeat steps B and C. Voltage at C53 + must be 8 0.5 volts.

4.4.2 Attenuator

To check the midband attenuator operation proceed as follows:

A. On the 1 mV range put in a signal to produce a precise deflection at some point, e.g. 5 or 10 on the scale.

B. Increase the input by precise factors of 3.162 (10 dB) advancing the range knob accordingly. Note the deviation from the initial indication; these should be within ±0.25% maximum.

C. If the deviations on the 3 mV, 10 mV, or 30 mV ranges exceed ±0.25%, reduce these by adjusting the 3 mV LF adjustments (see Fig. 13) for better agreement with the 1 mV range.

4.4.3 Sensitivity

To adjust the sensitivity proceed as follows:

A. Complete the checks outlined in sections 4.4.1 and 4.4.2.

B. Connect a signal of precisely 1 V rms, 400 Hz to 1 kHz, on the 1 V range. Successively, set the input signal to 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.25, 0.2, 0.15, 0.1 volts noting the magnitude and sign of the error at each point.

C. Adjust the SENS control (see Fig. 13) so that the maximum positive and maximum negative errors obtained in step B are equal.

4.4.4 DC Output

To adjust the dc output proceed as follows:

A. Connect a signal to produce an indication of precisely 10 on the scale, and note the dc output voltage. If this is not −1.0, ±1% V, adjust the DC OUT control (see Fig. 13) for this condition.

B. Reduce the input voltage by a precise factor of 0.3162 (10 dB). The dc output voltage should be −100, ±3% mV. If this is not obtained recheck the scale adjustment as outlined in section 4.4.1.

4.4.5 NULL Operation

To check the NULL operation proceed as follows:

A. With the MODE switch on METER connect a signal to produce an indication of 0 db on the meter.

B. Set the MODE switch to NULL and note the increase in indication; this should be at least 6.5 dB on the dB scale.

5. SERVICE AND TROUBLESHOOTING

5.1 General

In case of voltmeter malfunction, servicing by the user is feasible, provided skilled personnel using recommended equipment follow the procedures outlined below. However, it should be pointed out that these procedures are somewhat simplified; refined servicing and calibration may require special equipment not generally available to the user. If this is the case, or if trouble develops which cannot be corrected by the procedures outlined, the instrument should be returned to Ballantine Laboratories, Inc. for servicing. In all cases the instrument should be preceded by a letter stating the exact nature of the trouble and/or the desired servicing.

5.1.1 Equipment Required

A. An accurate, high impedance dc voltmeter, covering at least the range of 1 mV to 100 V. The Ballantine Model 365 is recommended.

B. An accurate, low resistance dc ammeter covering at least the range of 100 μA to 150 mA. The Ballantine Model 365 is recommended.

C. A variable frequency generator or generators covering a frequency range of 10 Hz to 20 MHz, with an output of 1 mV to 10 V or higher.

D. Wideband level monitor or monitors, covering a frequency range of 10 Hz to 20 MHz. The Ballantine Model 440 Micropotentiometers, and Ballantine Model 393 HF Transfer Voltmeter are recommended.

E. A sensitive, accurate, high impedance ac voltmeter covering a frequency range of at least 60 Hz to 1000 Hz, and a voltage range of at least 100 μV to 10 V. The Ballantine Models 300H, 302C, 310B, 320A, 321 are recommended.

5.2 Line Voltage Conversion

To change the operating line voltage of this instrument proceed as follows:

A. Remove instrument cover.

B. Locate line voltage switch at lower left hand corner of the rear panel (while facing the front of the instrument).

C. Move the switch to its upper position for 120 V operation, to the lower position for 240 V operation.

D. If the voltage chosen in step C does not agree with that on the decal located on the rear cover, revise the decal marking to avoid damage or malfunction.

E. Install a fuse consistent with the line voltage, chosen as follows:

Line	323	323-01
120 V	1/10 A, Slo-Blo	1/16 A, Slo-Blo
240 V	1/16 A, Slo-Blo	1/32 A, Slo-Blo

5.3 Access to Instrument Adjustments, Components

The instrument adjustments are shown in Figs. 12, 13, and 14.

To gain access to these adjustments, proceed as follows:

A. Remove the two flat head screws securing top cover to instrument and remove the cover.

B. Remove the four screws securing the right side rail to instrument and remove the side rail. All the side adjustments are now accessible through the holes in the internal shield.

C. To gain access to the rear adjustments and other components, remove the four screws securing the internal shield and remove the shield.

D. To expose the front adjustments, remove the ground strap, three knobs, four screws securing the bottom plate (remove the plate), and three screws securing the front escutcheon plate; remove the escutcheon plate.

5.4 Battery Charging Current, 323 Only

To check the battery charging current, proceed as follows:

A. Disconnect the lead at the positive 12 V terminal of the battery.

B. Connect a low resistance current meter between the positive terminal and the lead disconnected.

C. With the instrument connected to the line, set the MODE switch to BATT CHG. The current meter should indicate approximately 120 mA. In early units, if necessary, adjust R78, the CHG RATE control, for 120 mA ±3 %.

5.5 Battery Replacement, 323 Only

To replace the battery in the Model 323, proceed as follows:

A. Unscrew the knurled nuts* on the battery terminals and remove leads.

B. Remove the screws securing the battery retainer to the chassis.

C. Install new battery, reversing above procedure.

D. In all of the above take precautions to avoid shorting the batteries with tools, leads, etc.

5.6 Chopper Drive Adjustments

To adjust the chopper drive frequency proceed as follows:

A. On any range connect a signal of 94 Hz ±0.25% to the input terminals of the instrument, and adjust the amplitude for an up scale meter indication.

B. Adjust the CHOP FREQ control (see Fig. 14) for zero (or as close to zero as possible) beat as noted by meter fluctuation.

To adjust the chopper drive symmetry proceed as follows:

A. Connect the test circuit shown in Fig. 15.

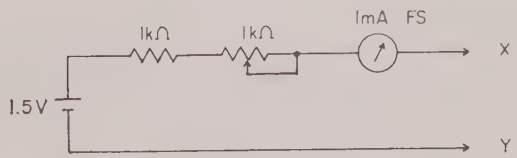


Fig. 15. Chopper Drive Symmetry Adjustment Circuit

B. Connect test prods X & Y together and adjust the 1 KΩ pot for a full scale indication of 1 mA.

C. Set the instrument RANGE switch to 300 V with zero input signal, MODE switch to METER.

D. Connect test prods X & Y to chopper terminals 7 & 6, and then terminals 7 & 1, noting the indication in each case. These indications should be slightly less than 500 μA and should be equal. If they are not equal, adjust for this condition with CHOP SYM control (see Fig. 14).

*Early production units employed two distinct batteries with soldered leads to tabs on one unit; here these leads would have to be unsoldered.

5.7 Chopper Replacement

To replace the chopper in this instrument proceed as follows:

A. Unsolder all leads from the chopper. Note carefully where each lead is attached.

B. Loosen the clamping screw on the chopper mounting strap.

C. Remove the old chopper.

D. Insert new chopper into mounting strap and retighten clamp screw.

E. Rewire all leads making certain that flexible leads from the amplifier assembly board are short and provide sufficient strain relief and flexibility to minimize audible noise and assure reliable performance during vibration.

F. Remove all solder-flux and other foreign material by cleaning with a solvent such as acetone or pure grain alcohol. In areas where high humidity is frequently encountered, coat the connections and terminals with a moisture-resistant coating such as Humiseal 1A27.*

5.8 Transistor Replacement

All of the transistors in this instrument are operated well within their maximum ratings and it should normally never be necessary to replace any unit. Because of the wide variation or spread in transistor parameters it is necessary in an instrument of this type to do a certain amount of selection and matching. Those units which are selected are so indicated on the Replacement Parts List, Section 7.

If replacement should become necessary, unselected units may be replaced with a unit of the same type designation. Selected units should be obtained from Ballantine Laboratories, Inc. In ordering a selected unit give the type, symbol designation (Q1, Q2, etc.) and color code (center dot, side dot, etc.) if any.

In removing and replacing a transistor (or other component) care should be exercised to avoid damage to the printed circuit board. Land areas on the board may lose their adhesion if subjected to excessive heat and pressure. A procedure to minimize the possibility of damage is to:

A. Clip the transistor or component leads on the component side of the board to remove the defective item.

B. With pliers or tweezers remove the lead from the component side of the board while heating the solder on the reverse side.

C. With the solder on the land area still molten, insert a scriber or other pointed tool into the lead hole (solder side) keeping it there until the solder solidifies after heat removal. Push out any solder which may have solidified in the hole from the solder side of the board.

D. When inserting the leads of the new component, check to see that they pass through the circuit board hole freely and exert no pressure on the land area on the solder side of the board.

E. After lead insertion carefully solder using a non-corrosive flux. Clean all flux and other residue from the affected area of the board with a solvent such as acetone or pure grain alcohol.

F. In areas of high humidity the affected area should be coated with a moisture-resistant coating such as Humiseal 1A27.

5.9 High Frequency Adjustments

The high frequency performance of this instrument is determined by the input attenuator, the wideband amplifier, the output attenuator, and rms detector. Each of these items except for the rms detector has a control or controls for adjusting the high frequency performance. These controls have been adjusted during the calibration at Ballantine Laboratories, Inc. and should seldom, if ever, require readjustment. Before any readjustment is made it should be fully established that readjustment is necessary, and the procedures outlined in this section should be followed.

The controls involved may affect all ranges, a group of ranges, or a certain sequence of ranges. In making a readjustment it is necessary to follow a sequence for proper results. Table V gives a listing of the controls affecting the high frequency performance of each range. On any range the performance should be checked for each adjustment listed, in a left to right sequence. Thus on the 3 V range it would be necessary to check (and readjust if required)

First — 1 mV range

Second — 30 mV range

Third — 100 mV range

*Columbia Technical Corporation, 24-30 Brooklyn Queens Expressway West, Woodside, N. Y.

REPLACING CHOPPER IN OLDER 323 SERIES INSTRUMENTS

To replace chopper 14-030099-0A which is identified by its mounting directly to the amplifier printed wiring board with new chopper 18-030099-0B which is mounted in a padded clamp tied to the BNC connector on the rear power supply printed wiring board follow the instructions detailed below.

Required Parts -- Chopper replacement kit is supplied whenever P/N 14-030099-0A is ordered.

1 ea. Chopper, P/N 14-03099-0B
1 ea. Clamp, P/N 49-10040-1A
1 ea. Cushion, P/N 53-10113-0A
1 ea. Teflon Standoff, P/N 65-08726-0A
1 ea. BNC Lockwasher, P/N 61-05311-0A
2 ea. 1" pieces of flexible Braid, P/N 79-10053-0A

Installation Procedures:

A. Unsolder the four leads connected to the base terminals noting where each is attached.

B. Remove the two screws securing the chopper to the printed circuit board.

C. Remove the top connector and remove the chopper.

D. Remove the flat plate between the front and rear frames at the top of the instrument and slide it out of the way.

E. Unsolder the wire to the DC output BNC connector on the rear printed wiring board. Remove the retaining nut from the BNC connector.

F. Locate the printed symbol "C46" on the amplifier printed wiring board. Carefully counter sink the hole near symbol C46 and insert the Teflon standoff (P/N 65-08726-0A) into the printed wiring board.

G. Take the free end of capacitor C46 that had previously been removed and solder it to the Teflon standoff.

H. Install the rubber cushion (P/N 53-10113-0A) into mounting clamp (P/N 49-10040-1A).

I. Hold the mounting clamp with the large mounting holder upright and the clamp ring facing you. Slip the chopper (P/N 14-03099-0B) into the cushioned clamp so that the terminal end is facing to the left and tighten the clamp screw.

J. Attach the clamp with cushion and chopper installed onto the BNC connector threaded portion protruding through the power supply printed wiring board. Then fit the lockwasher over the BNC and replace the BNC nut to hold the BNC connector and clamp in place. Make sure no part of the chopper touches any printed circuit board or metal part. It may be necessary to loosen and retighten the clamp screw to properly position the chopper.

K. All units with serial numbers without prefix codes or prefix codes 023-0000 and below will use the above chopper, strap and cushion as a replacement.

L. Make connections to the terminals of the chopper. Use the flexible braid to connect the proper chopper input lead to C46 at the rear Teflon standoff and for the ground connection. The other connections should be flexible as well and long enough to provide strain relief for vibration reliability and to avoid mechanical chopper noise from being transmitted to the amplifier printed circuit board.

M. Replace plate between front and rear frames.

N. Check the unit and recalibrate if necessary.

Table V — High Frequency Adjustments vs. Range

Range	Control					
	1 mV HF	3 mV HF	30 mV HF	100 mV HF	10 V HF C4	10 V HF C6
1 mV	×					
3 mV	×	×				
10 mV	×					
30 mV	×		×			
100 mV	×			×		
300 mV	×	×		×		
1 V	×			×		
3 V	×		×	×		
10 V	×				×	×
30 V	×	×			×	×
100 V	×				×	×
300 V	×		×		×	×

× denotes that control at top of column influences that range.

The test setup of equipment to check the frequency response on any range is shown in Fig. 16. The connection between the Model 323 and the level monitor should be as short and direct as possible so that the signal at the input of each will be identical at high frequencies. The signal generator and level monitor must operate at levels consistent with the range to be checked. For ranges up to 300 mV the Ballantine Model 440 Micropotentiometer is recommended as a level monitor; for ranges from 1 V to 100 V the Ballantine Model 393 HF Transfer Voltmeter is recommended.

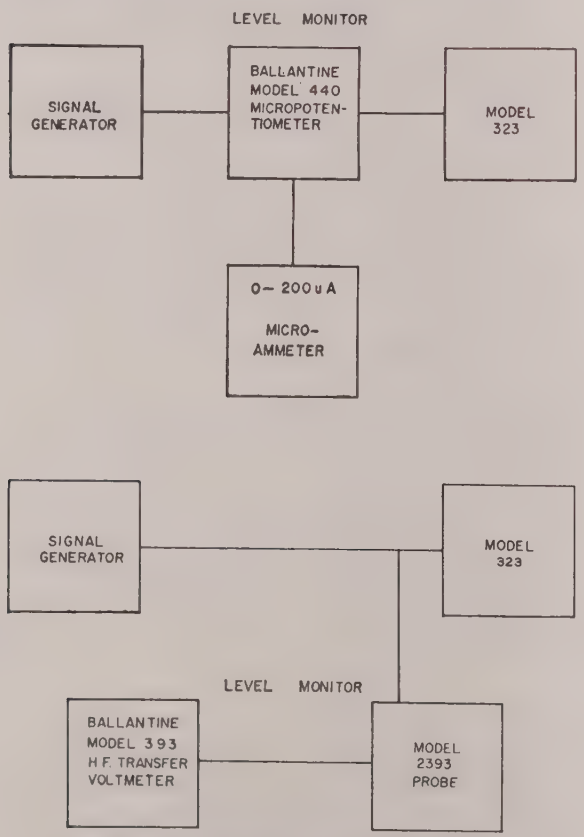


Fig. 16. Frequency Response Check

To check the 1 mV range proceed as follows:

A. At a frequency of 1 kHz set the amplitude for an on-scale indication (e.g. 1 mV) on the instrument and note the indication of the level monitor.

B. In succession set the generator frequency to 10 kHz, 100 kHz, 1 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz, adjusting the generator amplitude at each frequency for the same indication on the level monitor as was noted at 1 kHz. At each frequency also note the instrument indication. It is helpful to either tabulate or plot this response in % vs frequency. The 1 mV HF adjustment (see Fig. 13) should be adjusted (if necessary) for the flattest response to 10 MHz. A rise of approximately 0.5% at 10 MHz is typical and a further rise beyond this point is also typical and desirable. A typical response for the 1 mV range is shown in Fig. 17.

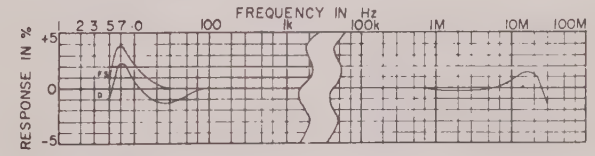


Fig. 17. Typical Frequency Response, 1 mV Range

The procedure for the adjustment of all other ranges is similar to that for the 1 mV range. In each case any adjustment made should be to provide flattest response to 10 MHz and best agreement with the 1 mV range. The 100 mV HF (C2) and 10 V HF (C4) adjustments control the response in the 100 kHz to 20 MHz region. The 10 V HF (C6) adjustment provides a further adjustment in 10 MHz to 20 MHz region.

5.10 Low Frequency Checks

The low frequency response of this instrument is determined primarily by the wideband amplifier and rms detector and hence is independent of range selector setting. There are no controls for adjustment; need for readjustment probably indicates a faulty component.

To check the low frequency response connect the in-

strument as shown in Fig. 16 and proceed as follows:

A. At a frequency of 1 kHz set the amplitude for an on-scale indication (e.g. 1 V) on the instrument and note the indication on the level monitor.

B. In succession set the generator frequency to 100 Hz, 50 Hz, 30 Hz, 20 Hz, and 10 Hz, adjusting the amplitude at each frequency for the same indication on the level monitor noted at 1 kHz. At each frequency also note the instrument indication. A typical low frequency response is shown in Fig. 17. It will be noted that the response at full scale and down scale are different below 50 Hz; this is inherent and normal.

5.11 Attenuator Repairs

The resistors used in the range attenuators of this instrument are a precision metal film type and are initially matched to a tolerance of ±0.1%, with temperature coefficients matched to ±100 ppm. If the procedure outlined in Section 4.4.2 reveals that an attenuator is in error, it is recommended that the entire attenuator involved be replaced with a matched set obtained from Ballantine Laboratories, Inc.

The attenuator actually causing the error can be isolated by the use of Table IV and the schematic Figs. 18 and 19.

Example: All ranges are normal except the 100 mV, 300 mV, 1 V and 3 V where an error of −6% is noted. Scanning Table IV would quickly reveal that the 40 dB input attenuator (R4, R5 and R6) is common to these four ranges and no others. The output attenuator would not be suspect since it is involved on the eight other ranges which are normal.

Example: The 30 mV, 3 V, and 300 V ranges exhibit an error of +2% with all other ranges normal. Table IV shows that the 30 dB output attenuator (R39 and R42) is common to these three ranges and no others.

Example: The only ranges normal are the 1 mV, 100 mV, and 10 V ranges. All other ranges exhibit approximately the same error of +7%. The use of Table IV, the schematic Figs. 18, 19, and a little reasoning would soon indicate that the 10 dB step of the output attenuator is in error.

In replacing attenuator resistor a few precautions should be observed:

A. Note the position of the original resistors and place replacement resistors similarly.

B. Avoid excessive heat while soldering; too much heat can cause shifts in the values of the attenuator resistors, and loss of spring tension in the attenuator switch clips.

C. When soldering use a non-corrosive flux and clean areas involved with a solvent such as acetone or pure grain alcohol.

If attenuator errors are experienced only at high frequencies and cannot be corrected by means of readjustment as outlined in 5.9, procedures similar to the above may be employed to isolate the defective component.

After any attenuator repair it is recommended that the checks outlined in Sections 4.4.2 and 5.9 be made.

5.12 Addition of Time Constants

It is possible to incorporate a third time constant in this instrument in addition to the two normally supplied (0.25 s, 0.5 s).* To accomplish this proceed as follows:

A. Remove the instrument cover, right side rail, and internal shield, to gain access to the RC TIME CONSTANT switch.

B. It will be noted that the switch, in addition to four capacitors, has four pieces of bus bar or shorting links running between the two decks. Remove the two links adjacent to the existing capacitors (180 ° apart).

C. In place of the two links removed in step B, observing the polarity of existing capacitors, solder in the two capacitors for the new time constant. See Table III for values. The capacitors used here must be of the highest quality. For the higher values tantalum electrolytics, such as the Sprague Type 150D, are recommended.

D. When soldering use only a non-corrosive flux and clean all surfaces involved to remove flux traces, etc. Acetone or pure grain alcohol is recommended as a cleaning agent.

E. It is possible to add a fourth time constant by removing the two remaining short links (see step B) adjacent to the switch strut screws. However, the RESET (see section 2.23) function would be lost for this time constant.

5.13 Troubleshooting

If it appears that the instrument is not operating properly, the possibility of a misadjustment should be eliminated first. Sections 4 and 5 outline checks useful for this purpose.

A visual inspection for broken leads, components, or other physical defects is sometimes a rapid method of locating a cause of malfunction.

In most cases it is possible to isolate the trouble to a particular circuit or section of the instrument. Fig. 11, simplified schematic, and Figs. 18, 19, schematic, will be found useful in this process.

5.13.1 DC Voltages

In many instances a defective component can be readily located by a check of pertinent dc operating potentials. All important dc operat-

*Early production units incorporated only one time constant 0.4 s, which was labelled NORMAL.

ing voltages are shown on the schematic Figs. 18, 19 located at the rear of this manual. It should be noted that the voltages shown are typical; with the wide variations encountered in transistor parameters, voltage variations of up to ±20% may be normal.

5.13.2 Signal Tracing

A highly successful method of locating a defective section or component is signal tracing. Signal voltages at all pertinent points are shown on the schematic Figs. 18, 19 at the rear of this manual. It should be noted that the signal goes through several frequency transformations as follows

A Input to rms detector signal fr quency
B RMS detector to chopper· 0 Hz (dc)
C. Chopper to linear detector: 94 Hz
D. Linear detector to meter and dc output: 0 Hz (dc)

5.13.3 Power Supply

The power supply employs a full wave solid state rectifier to convert ac of line frequency to dc for operating potentials and currents. Zener diodes as reference elements and transistors are employed to regulate the dc current or voltages. All the pertinent dc and ac potentials for this section are shown on the schematic Figs. 18, 19 at the rear of this manual. It should be noted that in the case of the Model 323, the batteries are essential to operation even when on line power; no attempt should be made to operate without batteries.

5.13.4 Chopper Drive

The chopper drive employs two transistors Q10, Q11 in a multivibrator driving a second pair of transistors Q12, Q13, as switches to connect a dc supply alternately across each half of the chopper drive coil. The schematic Figs. 18, 19 at the end of this manual shows all pertinent dc and ac voltages, as well as waveforms.

5.13.5 Troubleshooting Chart

Symptom	Possible Cause and/or Remedy	Pertinent Section
Instrument inoperative on battery power	Battery discharged (323 only) : recharge	2 4.2, 3.11, 5.4
	Battery defective (323 only) : replace	5 5
	MODE switch improperly set· reset	2 1, 2.5, 2.13
	RC TIME CONSTANT switch on RESET: set to 0 25 s*, 0.5 s	2.1, 2 23
Instrument inoperative on line power	Battery discharged (323 only) and	2.4.2, 3.11, 5.4
	Fuse blown: replace	
	Line cord defective: replace	
	Power supply defective: correct	3.11, 5.2.4
	Line voltage switch in wrong position: set to correct position	5.2
Instrument indication with no input	MODE switch on NULL. set to METER	2.1, 2.5, 2.13
	Defective chopper: replace	3.7, 5,7
	Amplifier oscillating correct	5.13, 5.13.1, 5 13.2, 5.13.3
Normal dc output but no meter indication	Defective meter: replace	2 21, 3.9
	Defective MODE switch: repair or replace	

*Early production units incorporated only one time constant marked NORMAL.

Symptom	Possible Cause and/or Remedy	Pertinent Section
Indications in error, all ranges	Scale misadjusted: reset	4.4.1
	Sensitivity misadjusted: reset	4.4.3
	Battery discharged (323 only) : recharge	2.4.2, 3.11, 5.4
	Defective meter: replace	
	MODE switch to NULL: set to METER	2.1, 2.5, 2.13
	Input leads unshielded: shield or use coax	
	Heavy ground current: reduce or eliminate	2.6.4
	Instrument in strong rf or magnetic field: reduce field by shielding or separation	2.6.6
	Wideband amp, rms detector, 94 Hz amp defective: correct	
Indications in error on 100 mV, 300 mV, 1 V, 3V ranges only	Defective or misadjusted 40 dB input attenuator (R4, R5, R6, C2, C3) : readjust, or isolate and correct defective component	4.4.2, 5.12
Indications in error on 10 V, 30 V, 100 V, 300 V ranges only	Defective or misadjusted 80 dB input attenuator (R7, R8, R9, R10, Cr, C5, C6) : readjust or isolate and correct defective component	4.4.2, 5.12
Indications in error on 30 mV, 3 V, 300 V ranges only	Defective or misadjusted output attenuator, 30 dB step (R39, R42, C27) : readjust or isolate and correct defective component	4.4.2, 5.12
Indications in error by same amount on 10 mV, 30 mV, 1 V, 3 V, 100 V, 300 V ranges only	Defective output attenuator, 20 dB step (R38, R41, C26) : isolate and correct defective component	4.4.2, 5.12
Indications in error by same amount on 3 mV, 10 mV, 30 mV, 300 mV, 1 V, 3 V, 30 V, 100 V, 300 V ranges, other ranges normal	R36 misadjusted: correct C25 misadjusted: correct Defective output attenuator, 10 dB step (R37, R40) : isolate and correct defective component	4.4.2, 5.12

6. SHIPPING INSTRUCTIONS

If it should be necessary to return the instrument to Ballantine Laboratories, please make certain that at least four inches of padding material surrounds the instrument to prevent damage during shipment. Ship via REA, UPS, motor truck, or air freight to

Ballantine Laboratories
90 Fanny Road
Post Office Box 97
Boonton, NJ USA 07005

A letter describing the malfunction and/or the desired servicing should precede the instrument.

7. REPLACEMENT PARTS LIST

The replacement parts listed are available from the vendors listed or from Ballantine Labs. at the address shown above. Your local Ballantine Field Engineering Representative may also carry a stock of parts and can assist you. If pricing quotations are required for parts and or repairs your local representative will give the most rapid service or you may contact the Ballantine Factory directly.

When ordering replacement parts always give the following information:

a) Instrument Model number
b) Serial number
c) Ballantine Part number
d) Schematic Symbol number
e) Identification of the part

Ballantine will do its best to improve the instrument and make changes in style of components and replacement parts. Replacement parts may differ in appearance from those found in your instrument but are always equal or superior in performance. Where necessary minor mechanical modifications may be required in the replacement of components.

Parts are generally available locally for most replacements. The parts list calls out the recommended vendors where applicable.

The Manufacturer Code is taken from Federal Supply Code Cataloging Handbooks H4-1, H4-2, and H4-3. Ballantine Code is 50423.

The following parts coding are used:

CVC	Capacitor, Variable, Ceramic
CCT	Capacitor, Ceramic, Tubular
CFP	Capacitor, Fixed, Plastic
CCD	Capacitor, Ceramic, Disc
CYF	Capacitor, Mylar, Foil
CMD	Capacitor, Mica, Dipped
CMM	Capacitor, Mica, Molded
CEA	Capacitor, Electrolytic, Aluminum
CET	Capacitor, Electrolytic, Tantalum
DGP	Diode, General Purpose
DHF	Diode, High Frequency
DZG	Diode, Zener, General Purpose
DRP	Diode, Bridge, Power
FLT	Filter
ICP	Integrated Circuit
RFF	Resistor, Fixed, Film
RFC	Resistor, Fixed, Composition
RVC	Resistor, Variable, Composition
RFW	Resistor, Fixed, Wirewound
TRQ	Transistor
SWC	Switch
LMP	Lamp
TRX	Transformer

Resistors may generally be replaced by Corning Electronics (CCW) type N-55, N-60, and C-32. Allen Bradley composition resistors type ER are also used.

INPUT ATTENUATOR 89100671A

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 1	07081380A	CMO 150 NF 600 V K+-10%	84171	ARCO 30P-5-154
C 2	07024540A	CVR 0.7 - 3 PF	72982	ERIE TYPE 535-000
C 3	07022820A	CMB 330 PF 500 V J 5%	72982	ERIE TYPE 653-015
C 4	07024540A	CVR 0.7 - 3 PF	72982	ERIE TYPE 535-000
C 5	07022320A	CMB 330 PF 500 V J 5%	72982	ERIE TYPE 653-015
C 6	07024460A	CVC 5.5 - 18 PF 350 V	72982	ERIE 538-002 NOP
C 7	07025470A	CCT 620 MP 500 V K+-10%	95121	QUALITY COMPONENTS TP QC
C 8	07025470A	CCT 620 MP 500 V K+-10%	95121	QUALITY COMPONENTS TP QC
R 1	12126000A	RFF 1.00M 500 MW F+-1%	16299	CGW RN60D 1004 F
R 2	12126000A	RFF 1.00M 500 MW F+-1%	16299	CGW RN60D 1004 F
R 3	12122000A	RFF 100.0 500 MW F+-1%	16299	CGW RN60D 1000 F
R 4	12060700A	RCF 1.0 M 500 MW F+- 1%	19701	ELT TYP MF6C CH-D
R 5	12060700A	RCF 1.0 M 500 MW F+- 1%	19701	ELT TYP MF6C CH-D
R 6	12060760A	RCF 20.2 K 250 MW F+- 1%	19701	ELT TYP MF5C CH-D
R 7	12060700A	RCF 1.0 M 500 MW F+- 1%	19701	ELT TYP MF6C CH-D
R 8	12060700A	RCF 1.0 M 500 MW F+- 1%	19701	ELT TYP MF6C CH-D
R 9	12060760A	RCF 20.2 K 250 MW F+- 1%	19701	ELT TYP MF5C CH-D
R 10	12060780A	RCF 202.0 250 MW F+- 1%	19701	ELT TYP MF5C CH-D
S 1	25077651F	SWC OAK TYPE F (RANGE)	50423	

OUTPUT ATTENUATOR AND DETECTOR 89100681A

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 25	07024410A	CVC 9. - 35. PF 200 V	72982	ERIE 538-002 N650 P C
C 26	07081160A	CCT 15 PF 500 V J 5%	95121	JUALITY COMPONENTS
C 27	07024410A	CVC 9. - 35. PF 200 V	72982	ERIE 538-002 N650 P C
C 35	07102570A	CET 2.7 UF 35 V K	56289	SPRG 196D275X9035JA1
C 36	07102570A	CET 2.7 UF 35 V K	56289	SPRG 196D275X9035JA1
C 38	07025830A	CMB1000 PF 500 V	01121	ALLEN-BRADLEY TYPE SB4A
C 39	07025830A	CMB1000 PF 500 V	01121	ALLEN-BRADLEY TYPE SB4A
C 43	07078400A	CEA 470. NF 35 V K 10%	56289	SPRAGUE 150D474X9035A2
C 44	07078400A	CEA 470. NF 35 V K 10%	56289	SPRAGUE 150D474X9035A2
CR 5	05100611A	DHF UHF DET MATCHED W/ CR6	50423	
CR 6	05100611A	DHF UHF DET MATCHED W/ CR5	50423	
R 35	12122000A	RFF 162.0 500 MW F+-1%	16299	CGW RN60D 1620 F
R 36	09019540A	POT 10.0K M+-20%	11236	CTS TYP X201
R 37	12060730A	RCF 136.8 250 MW F+- 1%	19701	ELT TYP MF5C CH-D
R 38	12060730A	RCF 136.8 250 MW F+- 1%	19701	ELT TYP MF5C CH-D
R 39	12060730A	RCF 136.8 250 MW F+- 1%	19701	ELT TYP MF5C CH-D
R 40	12060740A	RCF 92.5 250. MWF+- 1%	19701	ELT TYP MF5C CH-D
R 41	12060740A	RCF 92.5 250. MWF+- 1%	19701	ELT TYP MF5C CH-D
R 42	12060750A	RCF 63.2 250 MW F+- 1%	19701	ELT TYP MF5C CH-D
R 45	12125020A	RFF 105.0 K 500 MW F+-1%	16299	CGW RN60D 1053 F
R 46	12125020A	RFF 105.0 K 500 MW F+-1%	16299	CGW RN60D 1053 F
R 47	12125020A	RFF 105.0 K 500 MW F+-1%	16299	CGW RN60D 1053 F
R 48	12125020A	RFF 105.0 K 500 MW F+-1%	16299	CGW RN60D 1053 F
R 110	12123840A	RFF 7.50 K 500 MWF +-1%	16299	CGW RN60D7501F

AMPLIFIER 89100691A

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 10	07093760A	CEA 250 UF 15 V K 10%	90201	MAL TYP MTV 250DE15
C 11	07025920A	CMB1000. PF 1 KV K+-10%	84171	ARCO TYPE CCD-102
C 12	07056660A	CET 68 UF 20 V K 10%	56289	SPG TYP 150D686X9020S2
C 13	07102380A	CTE 150.0UF 15.0VK	56289	SPRAGUE 196D157X9015MA3
C 14		FACTORY SELECTED		
C 15		FACTORY SELECTED		
C 16	07024410A	CVC 9. - 35. PF 200 V	72982	ERIE 538-002 N650 P C
C 17	07025350A	CCD 10. PF	09023	GMC C-D TYPE BYA-6S1
C 18	07022400A	CMM 20 PF 500 V J 5%	84171	ARCO TYPE CM15-C-200-J
C 19	07102370A	CTE 100. MF 20. VK	56289	SPRAGUE 196D107X9020MA3
C 20	07025920A	CMB1000. PF 1 KV K+-10%	84171	ARCO TYPE CCD-102
C 45	07078200A	CEA 400 UF 16 V K -10+50%	73445	ET471X025A01 AMPEREX
C 46	07023940A	CMM 100 NF 200 V J 5%	56289	SPRAGUE TYPE 192P10452
C 47	07078200A	CEA 400 UF 16 V K -10+50%	73445	ET471X025A01 AMPEREX
C 48	07025930A	CMB 50. PF 1 KV K+-10%	84171	ARCO BYPE CCD-500
C 49	07025920A	CMB1000. PF 1 KV K+-10%	84171	ARCO TYPE CCD-102
C 50	07081180A	CMM 6.8NF 200 V J 5%	56289	SPRAGUE TYPE 192P
C 51	07078140A	CEA 1 UF 12 V T	56289	SPRAGUE 30D105G012AA4
C 52	07078140A	CEA 1 UF 12 V T	56289	SPRAGUE 30D105G012AA4
C 53	07078430A	CEA 75 UF 15 V K -10+50%	56289	SPRAGUE 30D756F015CC4
C 54	07025920A	CMB1000. PF 1 KV K+-10%	84171	ARCO TYPE CCD-102
C 55	07078160A	CEA 47 UF 20 V K 10%	56289	SPRAGUE 150D476X9020B2
C 56	07025920A	CMB1000. PF 1 KV K+-10%	84171	ARCO TYPE CCD-102
C 57	07023940A	CMM 100 NF 200 V J 5%	56289	SPRAGUE TYPE 192P10452
C 58	07025920A	CMB1000. PF 1 KV K+-10%	84171	ARCO TYPE CCD-102
CR 1	05079200A	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
CR 2	10079270A	TRQ 2N3638	07263	FAIRCHILD
CR 3	05079200A	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
CR 4	10079270A	TRQ 2N3638	07263	FAIRCHILD
CR 7	05079200A	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
CR 8	05079200A	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
CR 18	05079200A	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
CR 19	05079200A	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
G 1	14030990A	CPS CONTACT MODULATOR	81541	AIRPAX 33A-68
L 1	03062741A	CLE INDUCTOR	50423	
M 1	[1]18060461N	MTR 1000 OHMS 0 DB REF	50423	
M 1	[2]18060471L	MTR 600 OHMS 0 DBM REF	50423	
M 1	[5]18060481L	MTR 75 OHMS 0 DBM REF	50423	
Q 1	10079330A	TRQ 2N4221A FET	04713	MOTOROLA
Q 2	10080550A	TRQ 2N918	07263	FAIRCHILD
Q 3	10080550A	TRQ 2N918	07263	FAIRCHILD
Q 4	10079380A	TRQ	73445	AMPEREX A322
Q 5	10079380A	TRQ	73445	AMPEREX A322
Q 6	10079380A	TRQ	73445	AMPEREX A322
Q 7	10079270A	TRQ 2N3638	07263	FAIRCHILD
Q 8	10079380A	TRQ	73445	AMPEREX A322
R 11	12122680A	REF 511.0 500 MW F+-1%	16299	CGW RN60D 5110 F
R 15	12123000A	REF 1.0 K 500 MW F+-1%	16299	CGW RN60D 1001 F
R 16	12123680A	REF 5.11K 500 MW F+-1%	16299	CGW RN60D 5111 F
R 17		FACTORY SELECTED		
R 18	12121400A	REF 26.1 500 MW F+-1%	16299	CGW RN60D 26R1 F
R 19	12125280A	REF 196.0 K 500 MW F+-1%	16299	CGW RN60D 1963 F
R 21	12121000A	REF 10.0 500 MW F+-1%	16299	CGW RN60D 10R0 F
R 22	12123280A	REF 1.96K 500 MW F+-1%	16299	CGW RN60D 1961 F
R 23	12123000A	REF 1.0 K 500 MW F+-1%	16299	CGW RN60D 1001 F
R 24	12121480A	REF 31.6 500 MW F+-1%	16299	CGW RN60D 31R6 F
R 25	12124000A	REF 10.0 K 500 MW F+-1%	16299	CGW RN60D 1002 F
R 26	12123000A	REF 1.0 K 500 MW F+-1%	16299	CGW RN60D 1001 F
R 27	12121980A	REF 82.5 500 MW F+-1%	16299	CGW RN60D 82R5 F
R 50	12121980A	REF 82.5 500 MW F+-1%	16299	CGW RN60D 82R5 F
R 51	12122080A	REF 121.0 500 MW F+-1%	16299	CGW RN60D 1210 F
R 52	12122280A	REF 196.0 500 MW F+-1%	16299	CGW RN60D 1960 F
R 53	12124280A	REF 19.6 K 500 MW F+-1%	16299	CGW RN60D 1962 F
R 54	12121000A	REF 10.0 500 MW F+-1%	16299	CGW RN60D 10R0 F
R 55	12125680A	REF 511.0 K 500 MW F+-1%	16299	CGW RN60D 5113 F
R 56	12124280A	REF 19.6 K 500 MW F+-1%	16299	CGW RN60D 1962 F
R 57	09101060A	RVE 10.0 250.CMWM CERMET	73138	HEL TYPE 72PM-10

[1] Used only in 323, 323-01, and 323-20.
[2] Used only in 323-06 and 323-07.
[3] Used only in 323 and 323-06.
[4] Used only in 323-01 and 323-07.
[5] Used only in 323-12.

AMPLIFIER 89100691A (Continued)

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 58	12123760A	REF 6.19K 500 MW F+-1%	16299	CGW RN60D 6191 F
R 59	12125560A	REF 383.0 K 500 MW F+-1%	16299	CGW RN60D 3833 F
R 60		FACTORY SELECTED		
R 61	12122990A	REF 200.0 500 MW F+-1%	16299	CGW RN60D 2000 F
R 62	12084550A	REW 3.5 F+-1%	80031	MPC TYPE M61
R 63	12124520A	REF 34.8 K 500 MW F+-1%	16299	CGW RN60D 3482 F
R 64	09100080A	RVC 10.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 65	12125520A	REF 348.0 K 500 MW F+-1%	16299	CGW RN60D 3483 F
R 66	12124720A	REF 56.2 K 500 MW F+-1%	16299	CGW RN60D 5622 F
R 67	12123200A	REF 1.62K 500 MW F+-1%	16299	CGW RN60D 1621 F
R 68	09101070A	RVF 200.0 250.0MWK CER	73138	HEL TYPE 72PM-200
C 69	12092510A	RCF 10.4 M 500 MW F+- 1%	35929	CON TYP N4
R 70	12092510A	RCF 10.4 M 500 MW F+- 1%	35929	CON TYP N4
R 71	09100610A	RVF 2.0 K 0.5 W +-30%	73138	HEL TYP 72PM
R 93	12123680A	REF 5.11K 500 MW F+-1%	16299	CGW RN60D 5111 F
R 94	[2]	FACTORY SELECTED		
R 95	[2]12121170A	REF 15.0 500 MW F+-1%	16299	CGW RN60D 15R0 F

POWER SUPPLY AND CHOPPER DRIVER 89100701A

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
B 1	[3]85086030A	BNC 12 V,6 V TAP,1.2 AH	61637	NICAD TYPE MP,
C 62	07078360A	CEA 100 UF 64 V K -10+50%	73445	AMPEREX C437AR/H100
C 63	[4]07020960A	CEA 50. UF 15 V T	56289	SPRAGUE TYPE 300170A1
C 65	07023540A	CPF 150 NF 200 V K 10%	56289	SPRAGUE TYPE 192P
C 66	07023540A	CPF 150 NF 200 V K 10%	56289	SPRAGUE TYPE 192P
C 67	[2]07022640A	CMD 500 PF 300 V J 5%	84171	ARCO TYPE DM-15-501J
C [2]00	07025430A	CCD 1.5NF 3 KV M -20+80%	72982	ERIE 878 H1-K DISC Y5V
C 201	07025430A	CCD 1.5NF 3 KV M -20+80%	72982	ERIE 878 H1-K DISC Y5V
CR 9	05080580A	DGP 1N4006	15238	ITT
CR 10	05080580A	DGP 1N4006	15238	ITT
CR 11	05080580A	DGP 1N4006	15238	ITT
CR 12	05080580A	DGP 1N4006	15238	ITT
CR 13	[3]05080580A	DGP 1N4006	15238	ITT
CR 13	[4]05079100A	DZP 6.8V +15% 1N957B	27832	JUGHES
CR 14	[3]05079100A	DZP 6.8V +15% 1N957B	27832	JUGHES
CR 16	05079200A	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
CR 17	05079200A	DGP 1N4148 GE OR	07263	FAIRCHILD,FDH 600
F 1	[3]19028100A	FUS 1/10 A SLO-BLO	75915	LTF 313.100,3A OR EQUIV.
F 1	[3]19028060A	FUS 1/16 A SLO-BLO	75915	LTF 313.062 3AG OR EQUIV
F 1	[4]19028060A	FUS 1/16 A SLO-BLO	75915	LTF 313.062 3AG OR EQUIV
F 1	[4]19028110A	FUS 1/32 A SLO-BLO	75915	LTF 313.031,3A OR EQUIV.
Q 9	[3]10079290A	TRQ 2N555	04713	MOTOROLA
Q 10	10079270A	TRQ 2N3638	07263	FAIRCHILD
Q 11	10079270A	TRQ 2N3638	07263	FAIRCHILD
Q 12	10079270A	TRQ 2N3638	07263	FAIRCHILD
Q 13	10079270A	TRQ 2N3638	07263	FAIRCHILD
R 76	[3]12123280A	REF 1.96K 500 MW F+-1%	16299	CGW RN60D 1961 F
R 76	[4]12080260A	REC 430.0 3 W J+- 5%	75042	IRC TYP PW3
R 77	[3]12121400A	REF 26.1 500 MW F+-1%	16299	CGW RN60D 26R1 F
R 78	[3]12121400A	REF 26.1 500 MW F+-1%	16299	CGW RN60D 26R1 F
R 79	[3]12121640A	REF 46.4 500 MW F+-1%	16299	CGW RN60D 47R5 F
R 85	09100080A	RVC 10.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 86	09100080A	RVC 10.0 K 0.5 WK +-10%	73138	HEL TYP 72PM
R 87	12124640A	REF 46.4 K 500 MW F+-1%	16299	CGW RN60D 4642 F
R 88	12124640A	REF 46.4 K 500 MW F+-1%	16299	CGW RN60D 4642 F
R 89	12123240A	REF 1.78K 500 MW F+-1%	16299	CGW RN60D 1781 F
R 90	12123240A	REF 1.78K 500 MW F+-1%	16299	CGW RN60D 1781 F
R 91	12122080A	REF 121.0 500 MW F+-1%	16299	CGW RN60D 1210 F

[1] Used only in 323, 323-01, and 323-20.
[2] Used only in 323-06 and 323-07.
[3] Used only in 323 and 323-06.
[4] Used only in 323-01 and 323-07.
[5] Used only in 323-12.

POWER SUPPLY AND CHOPPER DRIVER 89100701A (Continued)

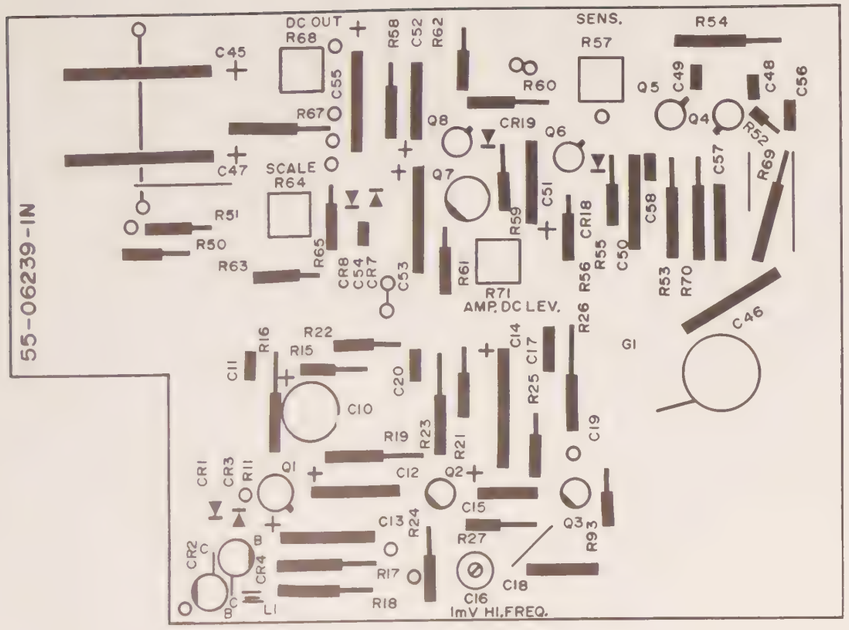
SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R 92	1212208[illegible]A	RES 121.0 500 MW F+-1%	16299	CGW RN60D 1210 F
R 100	1212140[illegible]A	RES 26.1 500 MW F+-1%	16299	CGW RN60D 26R1 F
R 101	1212220[illegible]A	RES 162.0 500 MW F+-1%	16299	CGW RN60D 1620 F
S 3	3 25100141 A	SWC 323 BAT &AC MODE	76854	OAK TYPE F
S 3	4 25077831 A	SWC MODE-AC ONLY	50423	
S 4	4 25077750 A	SWC SLIDE	79727	CON. WIRT TYPE G126 PC
T 1	2006262[illegible]	TRX 323 POWER	50423	MODEL 323
U 1	4 24100510 A	IC P 12 VOLT REG 78M12C 1/2A	07263	FAIRCHILD 78M12C OR EQUIV

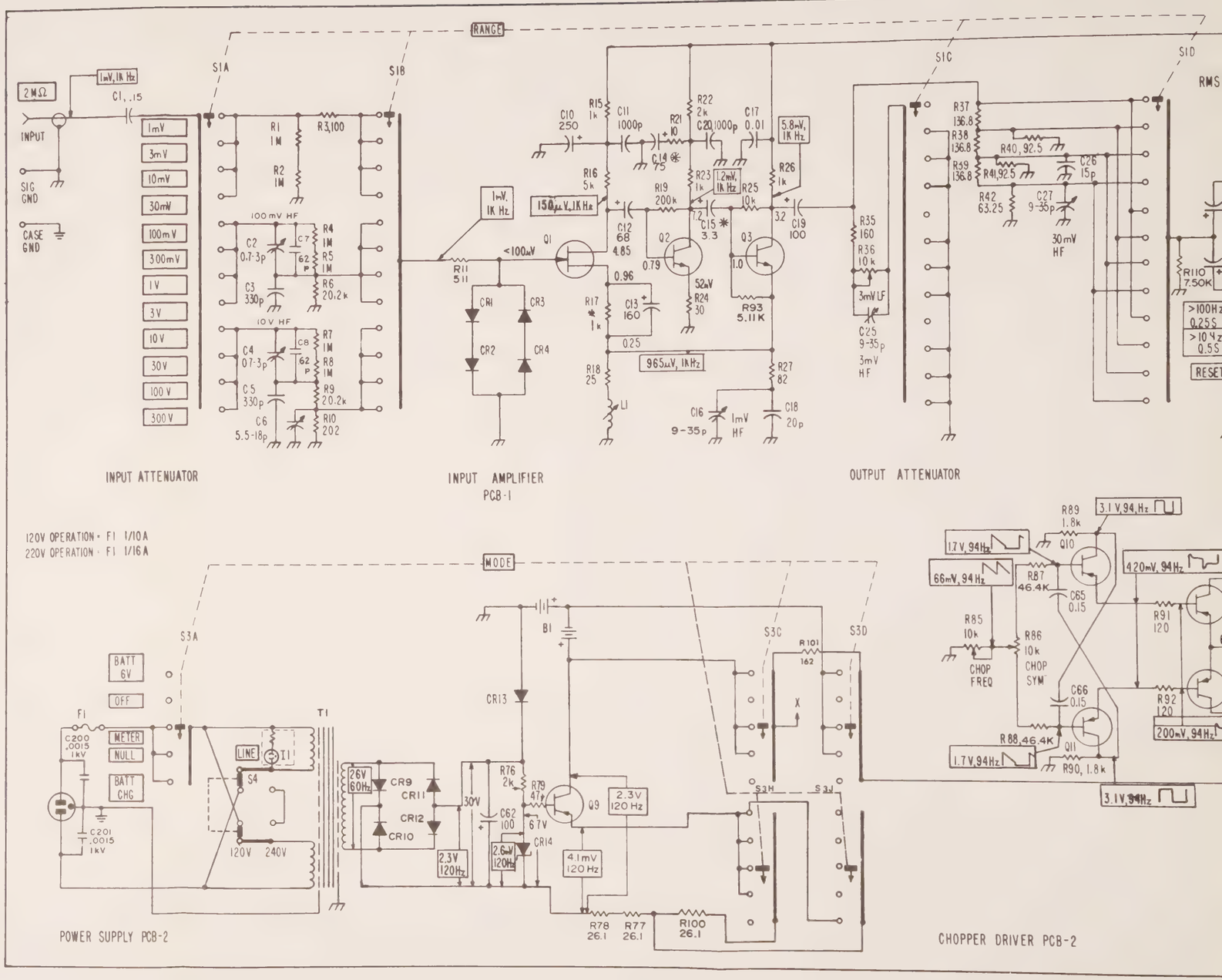
TIME CONSTANT SWITCH ASSEMBLY 89100781A

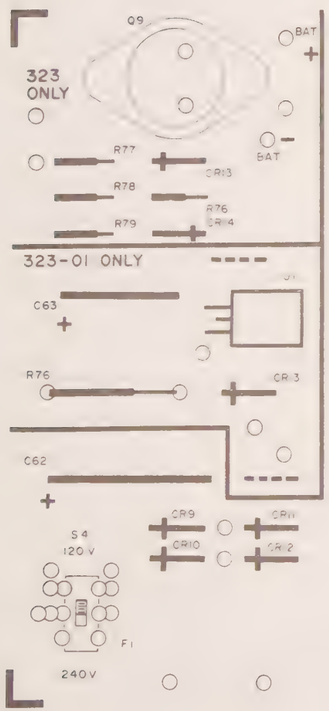
SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C 37	0710205[illegible]A	CYM 1.8UF 100.0 VM	14752	ELEC-CUB 230D18185 OR EQV
C 40	0710205[illegible]A	CYM 1.8UF 100.0 VM	14752	ELEC-CUB 230D18185 OR EQV
C 41	0708126[illegible]A	CMM 470.0NF 80 V K 10%	56289	SPRAGUE TYPE 192P4749R8
C 42	0708126[illegible]A	CMM 470.0NF 80 V K 10%	56289	SPRAGUE TYPE 192P4749R8
S 2	2507765[illegible]A	SWC OAK TYPE F	50423	(TIME CONSTANT)

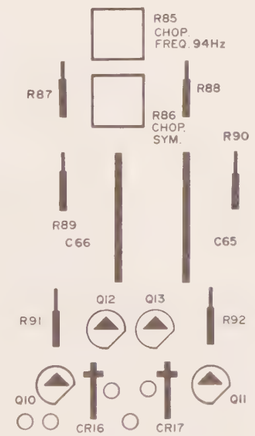
[1] Used only in 323, 323-01, and 323-20.
[2] Used only in 323-06 and 323-07.
[3] Used only in 323 and 323-06.
[4] Used only in 323-01 and 323-07.
[5] Used only in 323-12.

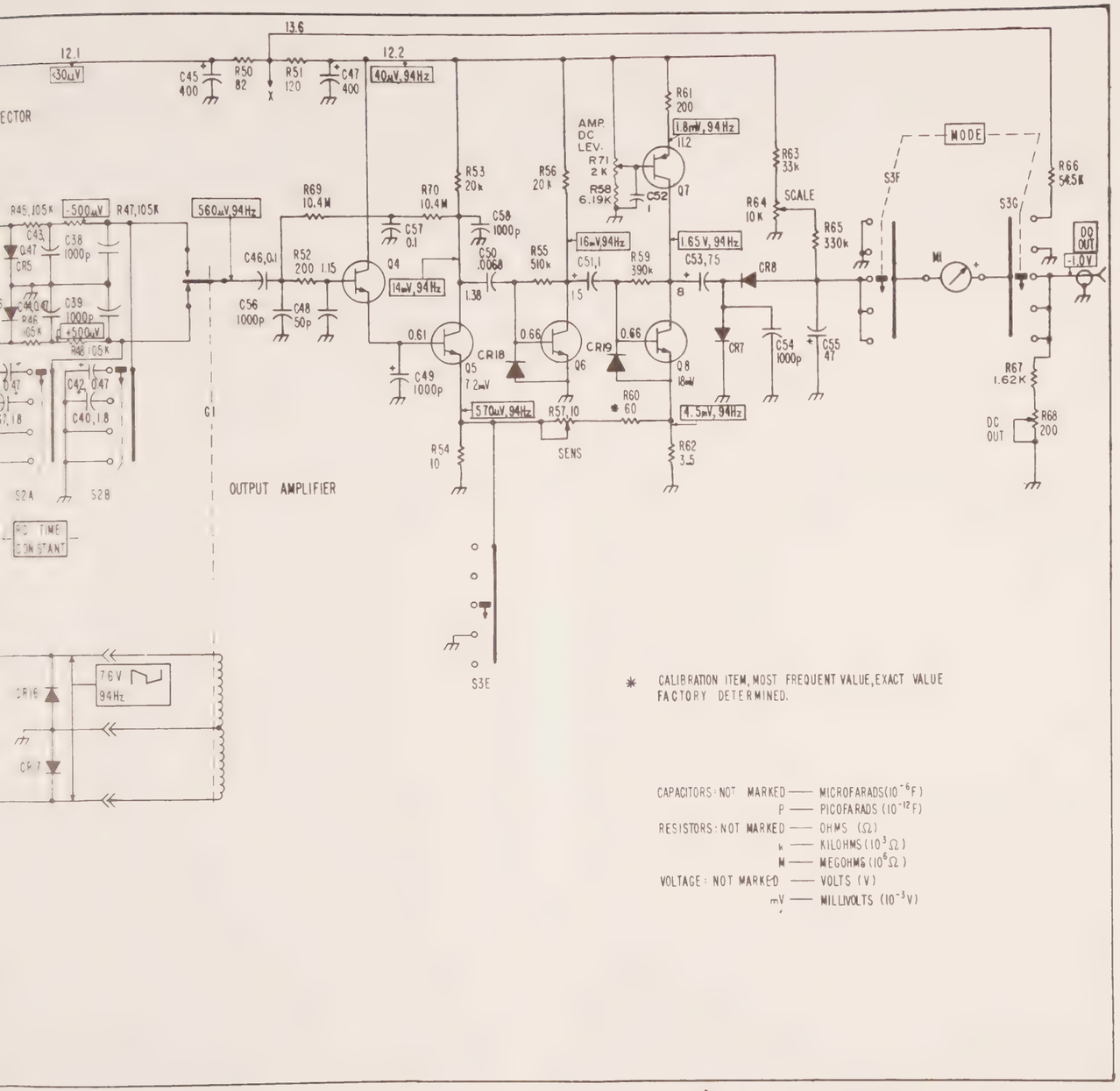
Notes


55-06239-IN
DC OUT
SENS.
SCALE
AMP. DC LEV.
1mV HI. FREQ.


RANGE
S1A
S1B
S1C
S1D
INPUT
SIG GND
CASE GND
2MΩ
1mV, 1K Hz
INPUT ATTENUATOR
INPUT AMPLIFIER
PCB-1
OUTPUT ATTENUATOR
120V OPERATION - F1 1/10A
220V OPERATION - F1 1/16A
MODE
S3A
S3C
S3D
S3H
S3J
BATT 6V
OFF
METER
NULL
BATT CHG
LINE
S4
120V 240V
POWER SUPPLY PCB-2
CHOPPER DRIVER PCB-2
CHOP FREQ
CHOP SYM
RESET


323 ONLY
323-01 ONLY
S4
120 V
240V

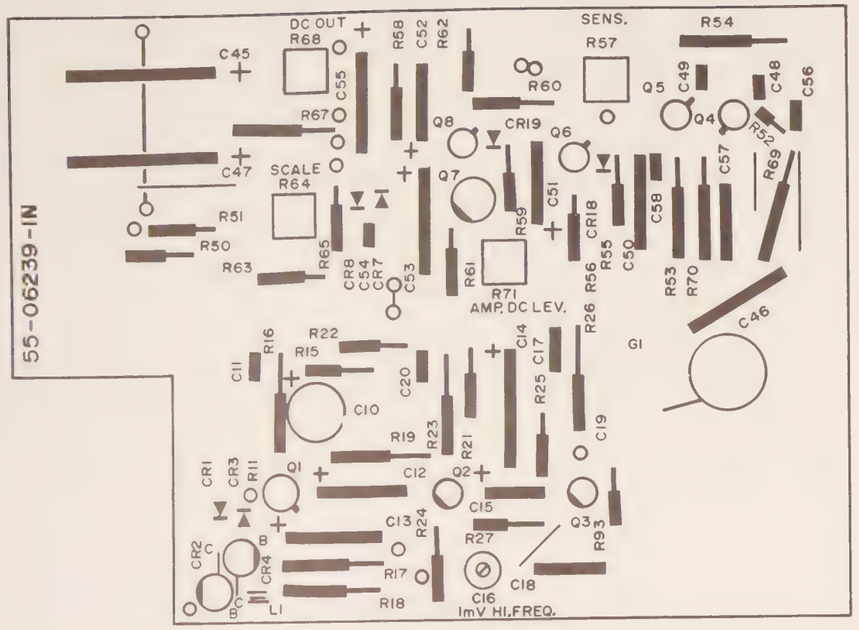

R85
CHOP. FREQ. 94Hz
R86
CHOP. SYM.

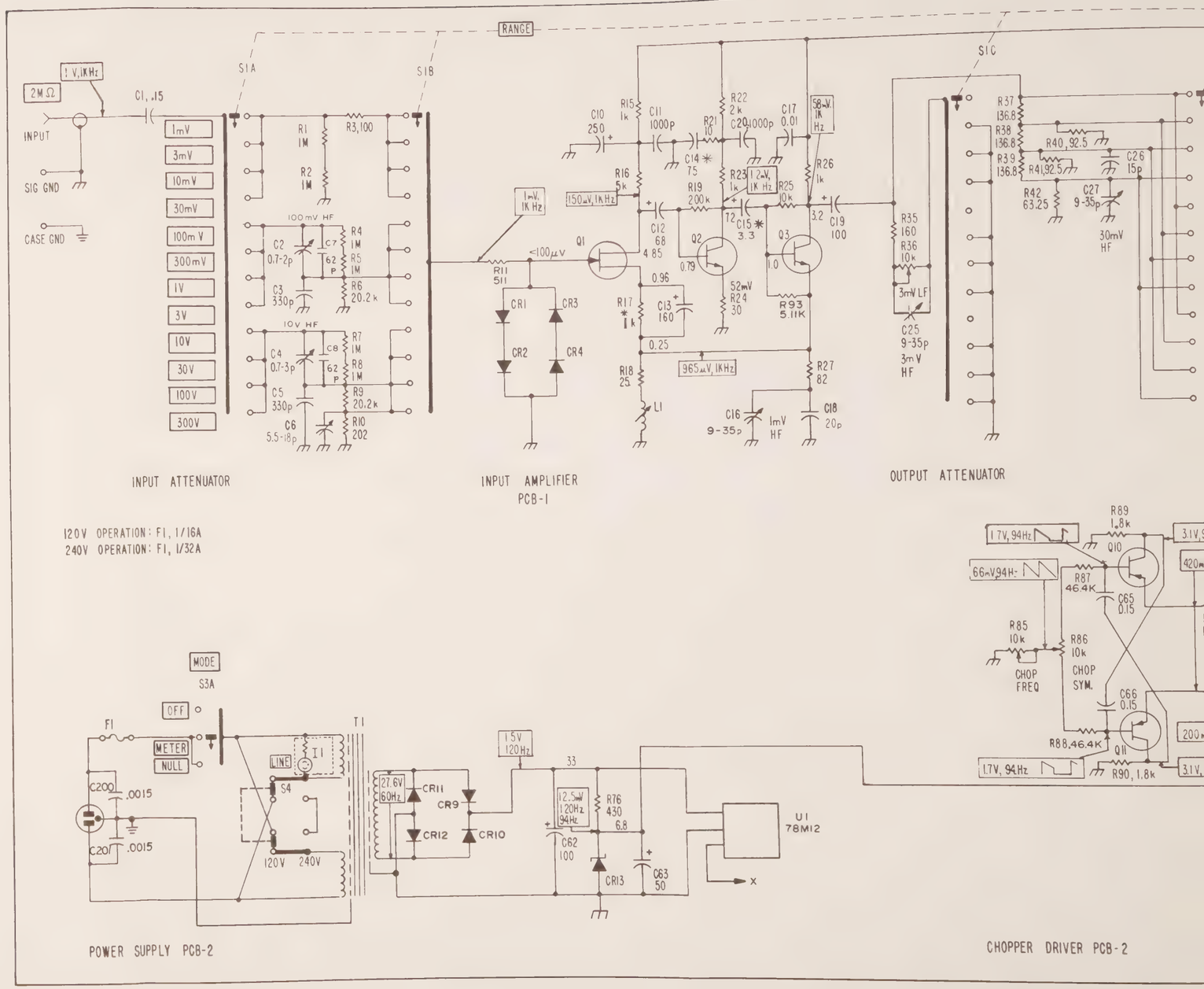


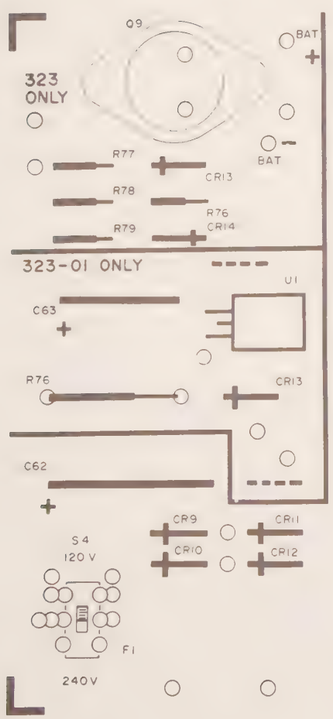
* CALIBRATION ITEM, MOST FREQUENT VALUE, EXACT VALUE FACTORY DETERMINED.

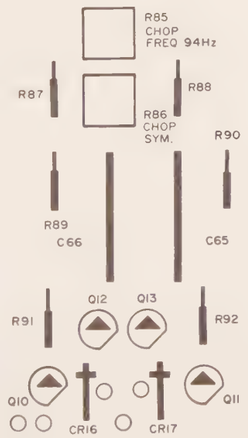
CAPACITORS: NOT MARKED — MICROFARADS (10^{-6}F)
P — PICOFARADS (10^{-12}F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3}Ω)
M — MEGOHMS (10^{6}Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3}V)

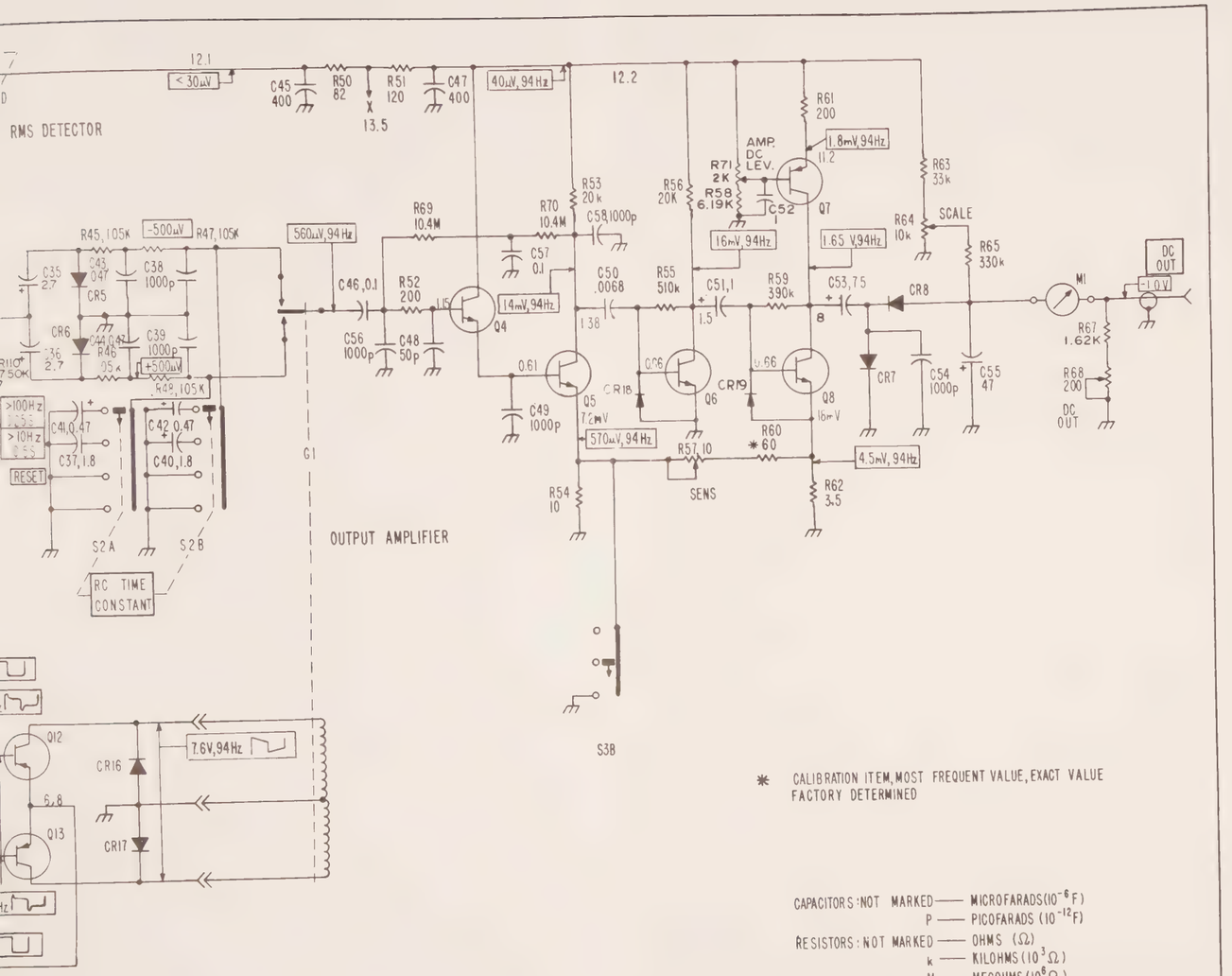
Fig. 18. Schematic and Component Locations, Model 323 (Serial No. 2195 and higher)


55-06239-IN
DC OUT
SENS.
SCALE
AMP. DC LEV.
1mV HI. FREQ.


RANGE
S1A
S1B
S1C
1 V, 1KHz
2MΩ
INPUT
SIG GND
CASE GND
C1, .15
1mV
3mV
10mV
30mV
100mV
300mV
1V
3V
10V
30V
100V
300V
100mV HF
10V HF
1mV, 1KHz
<100μV
150μV, 1KHz
965μV, 1KHz
1.2V, 1K Hz
56mV 1K Hz
3mV LF
30mV HF
INPUT ATTENUATOR
INPUT AMPLIFIER
PCB-1
OUTPUT ATTENUATOR
120V OPERATION: F1, 1/16A
240V OPERATION: F1, 1/32A
MODE
S3A
OFF
METER
NULL
LINE
120V 240V
1.5V 120Hz
27.6V 60Hz
12.5W 120Hz 94Hz
1.7V, 94Hz
66mV 94Hz
CHOP FREQ
CHOP SYM.
POWER SUPPLY PCB-2
CHOPPER DRIVER PCB-2


323 ONLY
323-01 ONLY
240V


CHOP FREQ 94Hz
CHOP SYM.
CR16
CR17



* CALIBRATION ITEM, MOST FREQUENT VALUE, EXACT VALUE FACTORY DETERMINED

CAPACITORS: NOT MARKED — MICROFARADS (10^{-6} F)
P — PICOFARADS (10^{-12} F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3} Ω)
M — MEGOHMS (10^{6} Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3} V)

Fig. 19. Schematic and Component Locations, Model 323-01 (Serial No. 2195 and higher)

APPENDIX A

ADDENDUM

to

INSTRUCTION MANUAL

for

323 SERIES

TRUE RMS VOLTMETERS

DIFFERENCE INFORMATION

for

MODELS 323-06 and 323-07

Serial No. Prefix 030-

BALLANTINE LABORATORIES, INC.

P.O. BOX 97, BOONTON, N.J. 07005

INTRODUCTION

This addendum to the instruction manual for the 323 Series True RMS Voltmeters contains information for the 323-06 and 323-07 which differs from that contained in the manual for the 323 and 323-01. As noted in the manual, even though only Models 323 and 323-01 may be referenced, the information it contains is applicable to all models of the 323 Series, unless noted otherwise. Differences are noted by reference to a specific model number or by the use of a triangular symbol (◀) adjacent to the text or an illustration or table title, indicating that difference information is included in this addendum.

For cross-reference, the paragraph numbers used in this addendum are the same as those used in the basic manual. If the information in the manual is applicable without change, the paragraph number is not included in this addendum. For this reason, paragraph numbers in this addendum are not necessarily in consecutive order.

1. GENERAL INFORMATION

1.1 Features

The Model 323-06 operates from either line power or internal rechargeable batteries while the Model 323-07 operates from line power only.

The NULL mode of operation is replaced in the Models 323-06 and 323-07 by the METER +10 dB mode to provide an additional 300 uV full scale range.

Figure A-1. Model 323-06 True RMS Voltmeter

1.3 Technical Characteristics

VOLTAGE RANGE

Same as Model 323 except additional 300 uV full scale sensitivity when MODE switch is set to Meter +10 dB position.

CALIBRATION

True rms (effective heating value) of input waveform.

MIN/MAX SCALE INDICATION

100 uV to 330 V

DECIBEL RANGE

-78 dBM to +52 dBM (0 dBM = 1 mW/600 Ω)

FREQUENCY RANGE

2 Hz to 20 MHz (-3dB 0.5 Hz)

SCALE CALIBRATIONS

Log Voltage: .095 to .33 & .3 to 1.06
Linear dB: -8.2 to +2.6

ACCURACY (±% of Reading, unless otherwise indicated)

2 Hz	5 Hz	20 Hz	50 Hz	1 MHz	10 MHz	15 MHz	20 MHz
10%	5%	3%	1% of F.S. or 2% of Rdg. (Whichever is better)	2%	3%	5% (10% above 100 V)	

POWER

323-06: Ac line or internal battery operation
323-07: Ac line only

2. OPERATION

2.1 Function of Controls (See Fig. 3)

MODE Switch, 323-06

BATT 6V	Provides battery check; when meter indication is less than 0.6 on upper meter scale, batteries should be recharged.
METER +10 dB	Increases the sensitivity of all ranges by 10 dB. (i.e. 1 mV full scale range becomes 300 uV full scale)

2.4 Starting Procedure

2.4.1 Line Operation

Set the MODE switch to METER or METER +10 dB as desired. The LINE pilot lamp should glow.

2.4.2 Battery Operation, Battery Charge, 323-06 Only

Check the batteries by setting the MODE switch to BATT 6V; the meter must indicate 0.6 or greater on the upper scale. If the indication is under 0.6, the batteries must first be recharged. NOTE: On battery operation the LINE pilot lamp will not glow.

If the indication is 0.6 or greater, set the MODE switch to METER or METER +10 dB as desired.

2.4.3 Warmup Period

When the instrument has not been in operation for many months, or when it has been stored in an area of high humidity, or when the meter indication is less than 0.6 with the MODE switch at BATT 6V, allow a warmup period of at least one hour.

2.6 Possible Sources of Measurement Errors

2.6.1 Pointer Stays at Extreme Left

d. Input voltage lower than 300 uV (100 uV on METER +10 dB).

2.6.2 Pointer Stays at Extreme Right

b. MODE switch on METER +10 dB rather than METER.

2.6.3 Loading Error, Input Characteristics

Table 1 - Input Parameters vs Range

Ranges	RA	RB	RC	CA	CB	CC
300 uV - 30 mV	2 M Ω	>100 MΩ	>100 MΩ	25 pF	≅ 400 pF	≅ 0 PF*
100 mV - 300 V	2 M Ω	>100 MΩ	>100 MΩ	15 pF	≅ 400 pF	≅ 0 pF*

* With BNC input connector

2.7 Use of the dB Scale

The dBm scale on the Model 323-06 and Model 323-07 is referenced to 1 mW into 600 ohms. Each step of the range knob either adds or subtracts 10 dBm. Measurements can be made over a range from -78 dBm to + 52 dBm.

2.13 Use as Null Detector

(Not applicable to the 323-06 or 323-07.)

2.14 Measurements Below 300 uV

In the 323-06 and 323-07, setting the MODE switch to METER +10 dB increases the sensitivity of the instrument by 10 dB and accurate measurements can be made from 100 uV to 300 uV. In this mode of operation, the frequency range is restricted to 5 Hz to 10 MHz.

2.16 Overload Protection

The maximum safe input voltage as listed in row 1 of Table II applies down to 300 uV for the 323-06 and 323-07.

2.21 Measurement of Power

The 0 on the decibel scale of the Model 323-06 and Model 323-07 is referenced to 0.775 on the voltage scale.

3. CIRCUIT DESCRIPTION

3.1 Basic Circuitry

The basic circuitry of this instrument is shown in Fig. A-2, Simplified Schematic, while compete schematics, Figures A-3 and A-4, are included at the end of this appendix.

Tracing the signal, the ac input is attenuated as necessary, amplified in the wideband amplifier, again attenuated as required, converted to dc in the rms detector and then applied as a differential signal to a chopper stabilized amplifier. The amplified signal is then fed to the output amplifier where it becomes a single-ended output that provides both the current for the meter indicator and an output voltage available at the rear of the instrument. The output voltage varies as the square of the input voltage.

Since the basic sensitivity of the instrument is 1 mV full scale, it is necessary either to increase this sensitivity (METER +10 dB) or to attenuate the higher level signals. A pair of attenuators is used and Table IV shows attenuation vs range setting.

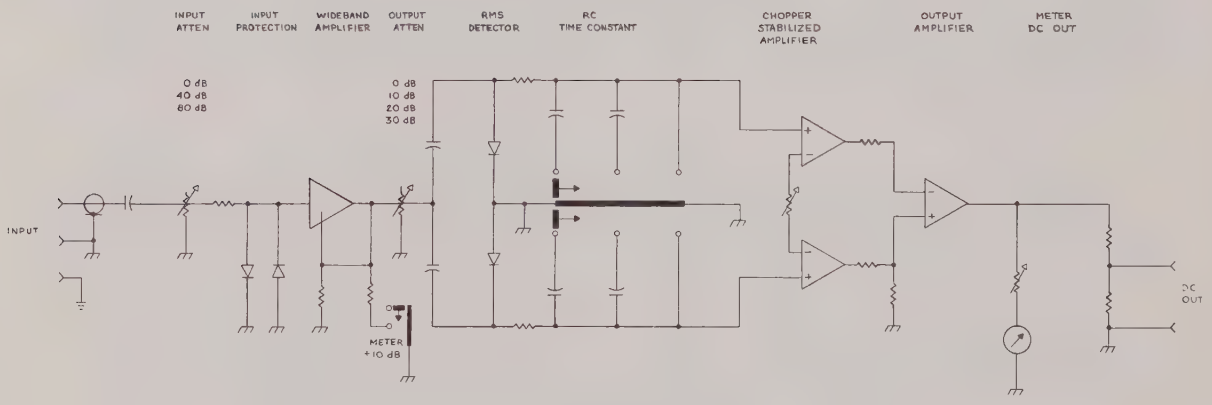


Figure A-2. Simplified Schematic, Models 323-06, 323-07

3.6 RMS Detector

The output of the rms detector is applied to a chopper stabilized differential amplifier.

3.7 Chopper Stabilized Amplifier

Two chopper stabilized operational amplifiers, U101 and U102, are arranged to provide a differential input that offers high gain while maintaining stability. The differential gain of this amplifier pair is adjusted for 60 dB; thus a 1 mV dc differential input voltage results in 1 V dc output voltage. R120 controls this gain and serves as a coarse sensitivity adjustment. Features of this chopper stabilized amplifier are extremely low input offset voltage combined with low drift as well as a very high common mode noise rejection.

3.8 Dc Output Amplifier

The amplified dc voltage is then converted to a single-ended input by operational amplifier U103. There, it is amplified another 10 dB and provides the low impedance drive for both the meter indicator and dc output. R109 is used to bias U103 and adjust the downscale accuracy of the dc output.

3.9 Meter and Dc Output

The output of U103 provides the dc current for the meter indicator, 600 uA being equivalent to the full scale indication. R114 serves as a fine sensitivity adjustment. The output is also applied to a voltage divider consisting of R116 and R117. The voltage developed across R117 is adjusted to be exactly +1.0 volt when the meter indication is full scale. This voltage is made available at the DC OUT terminals on the rear of the instrument and is not proportional to the meter indication as it follows a square-law response. Because of the low impedance output of U103 and the presence of R116, shorting the DC OUT terminals has negligible affect on the meter indicator. Loading of the DC OUTPUT with a resistance of 10 k Ω will cause the dc output voltage to drop approximately 10%.

3.10 Chopper Drive

The chopper drive circuit is no longer required in the Model 323-06 or 323-07 because the chopper has been replaced by a chopper stabilized amplifier.

4. MAINTENANCE

(Remove knobs, fornt panel, and covers to gain access to all internal adjustments and controls.)

4.4 Calibration

4.4.1 Coarse Sensitivity/DC OUT Adj (R120) and DC OUT Downscale Adj (R109)

A. Apply a 1.00 volt rms signal (between 400 Hz and 1 kHz) to the input terminals of the instrument with the RANGE switch set at 1V.

B. Connect a dc voltmeter to the DC OUT terminals at the rear of the instrument and adjust R120 for an indication of +1.00 volt dc on the dc voltmeter.

C. Reduce the input signal to 316.2 mV rms and observe the reading indicated on the dc voltmeter at the DC OUT terminals. If necessary, adjust R109 for +100.0 mV dc as measured on the dc voltmeter.

D. Change the input signal back to 1.00 volt rms and check that the voltage measured at the DC OUT terminals is +1.00 volts dc. If not, re-adjust R120. Repeat steps B and C until both requirements are satisfied.

4.4.3 Meter Sensitivity Adj (R114) and Meter Mechanical Adj (M1)

A. Repeat step 4.4.1 A.

B. Adjust R114 for a front panel meter indication of 10.

C. Reduce the input signal to 300 mV rms. Set the meter mechanical adjustment on the front of the meter case for a downscale meter indication of 3.

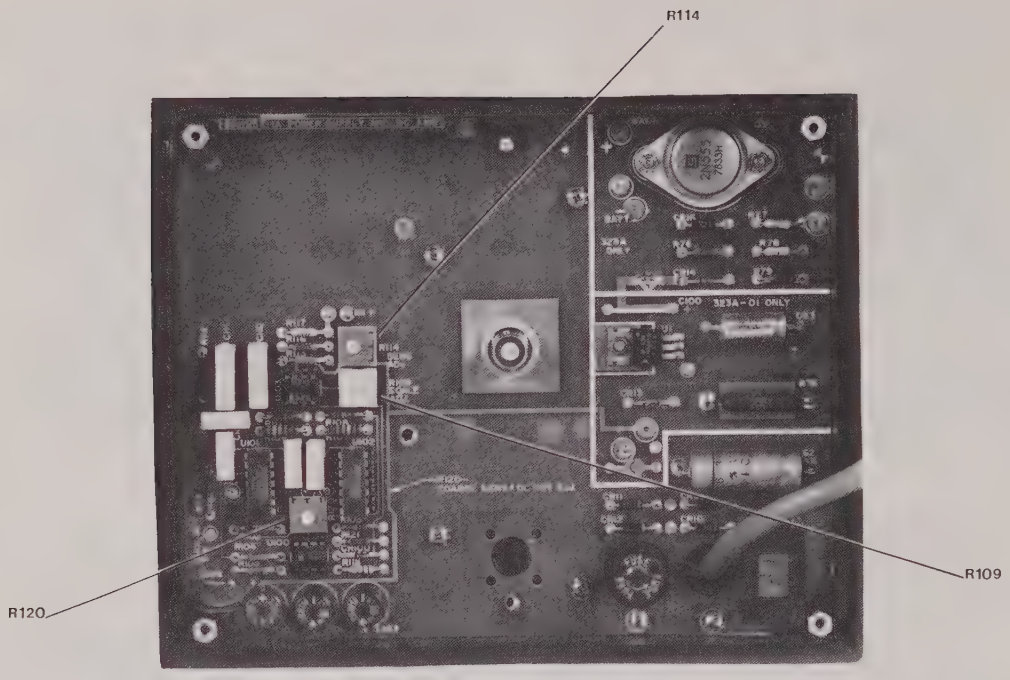


Figure A-3. Rear Adjustments

5. SERVICE AND TROUBLESHOOTING

5.6 Chopper Drive Adjustments

There are no chopper drive adjustments in the Model 323-06 or 323-07.

5.7 Chopper Replacement

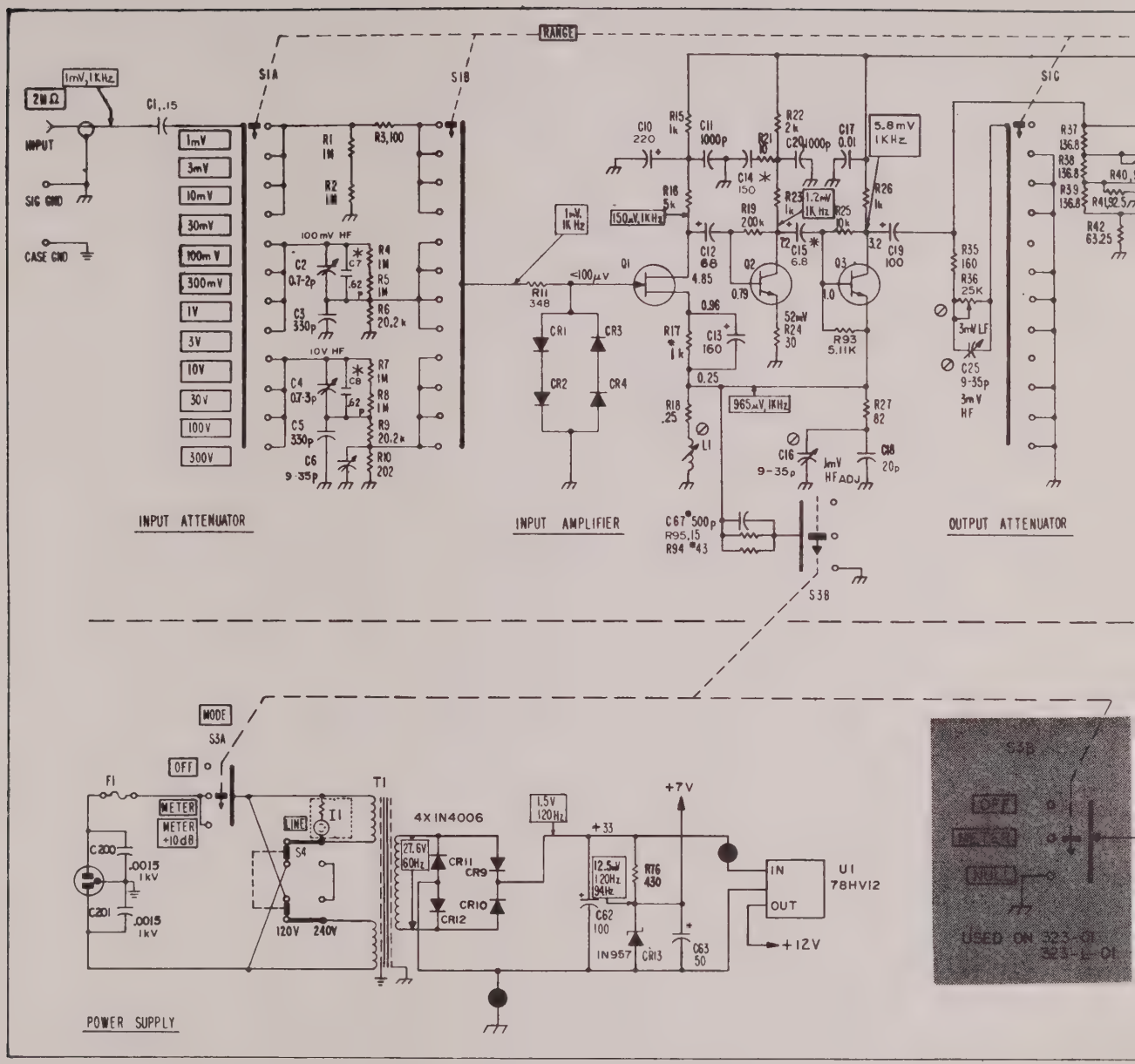
There is no mechanical chopper in the Model 323-06 or 323-07.

5.11 Attenuator Repair

Refer to Schematic Diagram Figures A-4 and A-5 in this Appendix.

5.13 Troubleshooting

Refer to Schematic Diagram Figures A-4 and A-5 in this Appendix. Disregard all troubleshooting references to the chopper and chopper drive circuits.


RANGE
S1A
S1B
S1C
2MΩ
1mV, 1KHz
INPUT
SIG GND
CASE GND
C1,..15
1mV
3mV
10mV
30mV
100mV
300mV
1V
3V
10V
30V
100V
300V
R1 1M
R2 1M
R3,100
100mV HF
C2 0.7-2p
C7
.62 p
R4 1M
R5 1M
C3 330p
R6 20.2k
10V HF
C4 0.7-3p
C8
.62 p
R7 1M
R8 1M
C5 330p
R9 20.2k
C6 9-35p
R10 202
INPUT ATTENUATOR
1mV, 1KHz
<100μV
R11 348
CR1
CR2
CR3
CR4
Q1
Q2
Q3
C10 220
R15 1k
C11 1000p
R21 15
R22 2k
C20 1000p
C17 0.01
5.8mV 1KHz
C14 150
R16 5k
150μV, 1KHz
R19 200k
R23 1k
1.2mV 1K Hz
R25 10k
R26 1k
C12 68
4.85
0.96
C15 6.8
3.2
C19 100
0.79
1.0
52mV
R24 30
R93 5.11K
C13 160
R17 1k
0.25
965μV, 1KHz
R18 .25
L1
C16 9-35p
1mV HF ADJ
C18 20p
R27 82
C67 500p
R95 15
R94 43
INPUT AMPLIFIER
R35 160
R36 25K
3mV LF
C25 9-35p
3mV HF
R37 136.8
R38 136.8
R39 136.8
R40
R41 32.5
R42 63.25
OUTPUT ATTENUATOR
S3B
MODE
S3A
OFF
F1
METER
METER +10dB
LINE
I1
S4
120V 240V
T1
C200
.0015 1kV
C201
.0015 1kV
4X IN4006
27.6V 60Hz
CR11
CR9
CR10
CR12
1.5V 120Hz
+33
+7V
12.5V 120Hz 94Hz
R76 430
C62 100
IN957
CR13
C63 50
IN
OUT
U1 78HV12
+12V
POWER SUPPLY
S3B
OFF
METER
MODE
USED ON 323-01
323-L-01

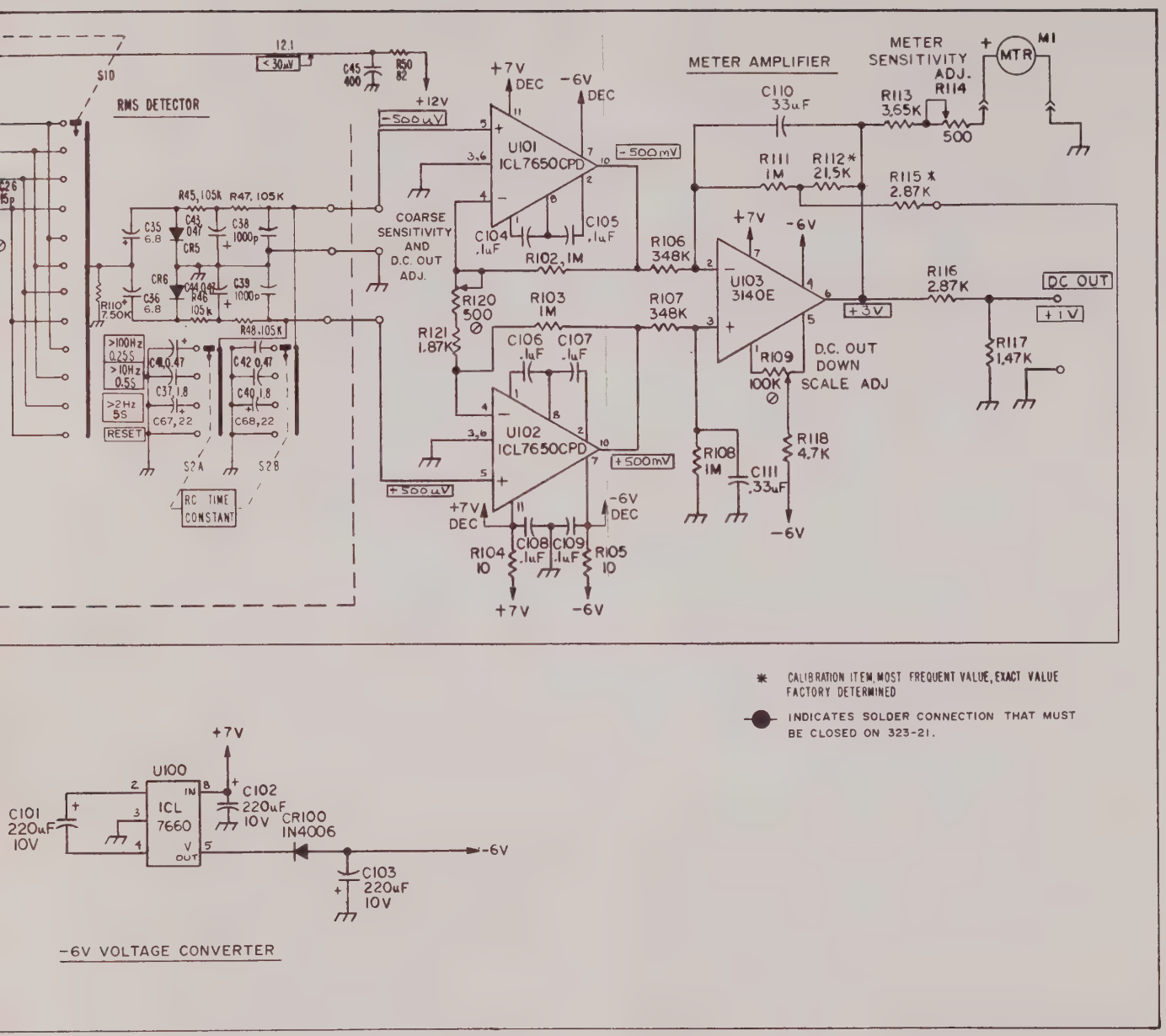
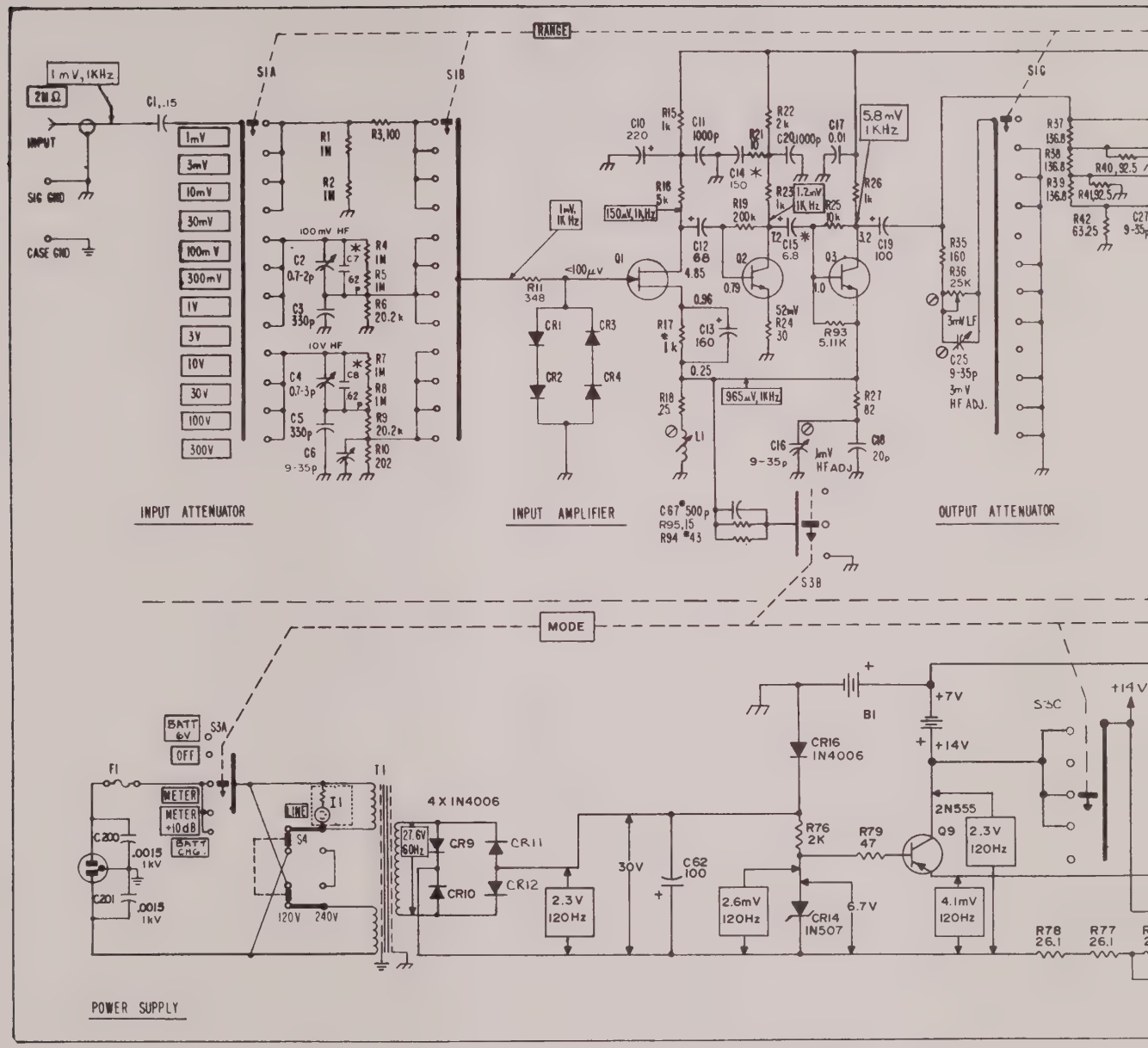


Figure A-4. Schematic, Model 323-06
(Serial No. Prefix 030-)


RANGE
1 mV, 1KHz
2MΩ
INPUT
SIG GND
CASE GND
C1, .15
S1A
S1B
1mV
3mV
10mV
30mV
100mV
300mV
1V
3V
10V
30V
100V
300V
R1 1M
R2 1M
R3, 100
100mV HF
C2 0.7-2p
C7
62 P
R4 1M
R5 1M
R6 20.2k
C3 330p
10V HF
C4 0.7-3p
C8
62 P
R7 1M
R8 1M
R9 20.2k
C5 330p
C6 9-35p
R10 202
INPUT ATTENUATOR
1mV, 1KHz
<100μV
R11 348
CR1
CR2
CR3
CR4
Q1
Q2
Q3
C10 220
R15 1k
C11 1000p
R22 2k
C21 10
C20 1000p
C17 0.01
5.8mV 1KHz
C14 150
R16 5k
150μV, 1KHz
R19 200k
1.2mV 1KHz
R23 1k
R25 10k
R26 1k
C12 68
4.85
0.79
T2
C15 6.8
3.2
C19 100
1.0
0.96
C13 160
52mV
R24 30
R93 5.11K
R17 1k
0.25
965μV, 1KHz
R27 82
R18 25
L1
C16 9-35p
1mV HF ADJ
C18 20p
C67 500p
R95, 15
R94 43
INPUT AMPLIFIER
SIG
R37 136.8
R38 136.8
R40, 92.5
R39 136.8
R41, 92.5
R42 63.25
C27 9-35p
R35 160
R36 25K
3mV LF
C25 9-35p
3mV HF ADJ.
OUTPUT ATTENUATOR
S3B
MODE
BATT 6V
OFF
S3A
F1
METER
METER +10dB
BATT CHG.
C200 .0015 1kV
C201 .0015 1kV
T1
I1
LINE
S4
120V
240V
27.6V 60Hz
4 X IN4006
CR9
CR10
CR11
CR12
2.3V 120Hz
30V
C62 100
B1
+7V
+14V
CR16 IN4006
R76 2K
R79 47
2N555
Q9
2.3V 120Hz
2.6mV 120Hz
CR14 IN507
6.7V
4.1mV 120Hz
S3C
+14V
R78 26.1
R77 26.1
POWER SUPPLY

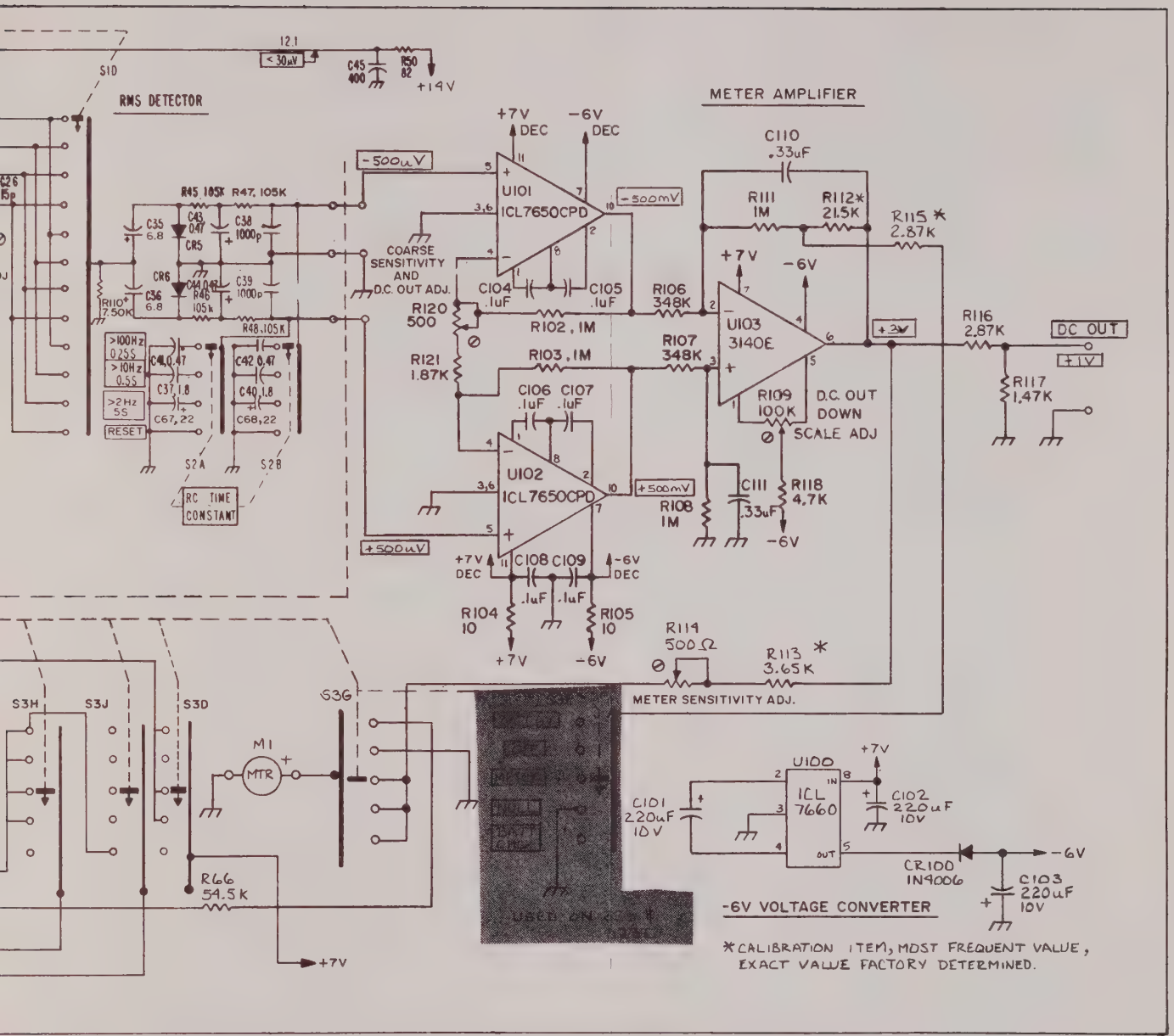


Figure A-5. Schematic, Model 323-07
(Serial No. Prefix 030-)

INPUT ATTENUATOR

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C1	07-08138-0A	CMD 150 NF 600 V K+-10%	84171	ARCO GDP-5-154
C2	07-02454-0A	CVP 0.7-3PF	72982	ERIE TYPE 535-000
C3	07-02282-0A	CMB 330 PF 500 V J 5%	72982	ERIE TYPE 653-015
C4	07-02454-0A	CVP 0.7-3PF	72982	ERIE TYPE 535-000
C5	07-02282-0A	CMB 330 PF 500 V J 5%	72982	ERIE TYPE 653-015
C...6	07-02441-0A	CVC 9.0-35PF200.0 V	72982	ERIE 538-002-DP-35
C7	07-02547-0A	CCT 620.0MF 500.0 VK+-10%	95121	QUALITY COMPONENTS TP QC
C8	07-02547-0A	CCT 620.0MF 500.0 VK+-10%	95121	QUALITY COMPONENTS TP QC
R1	12-12600-0A	RFF 1.00M 500 MW F+-1%	16299	CGW RN60D 1004 F
R2	12-12600-0A	RFF 1.00M 500 MW F+-1%	16299	CGW RN60D 1004 F
R3	12-12200-0A	RFF100.0 250.0MW F+-1%	16299	CGW RN55D 1000 F
R4	12-08859-1A	RFF	50423	TYP SET
R5	12-08859-1A	RFF	50423	TYP SET
R6	12-08859-1A	RFF	50423	TYP SET
R7	12-08860-1A	RFF 323 ATTEN MATCHED SET	50423	TYP SET
R8	12-08860-1A	RFF 323 ATTEN MATCHED SET	50423	TYP SET
R9	12-08860-1A	RFF 323 ATTEN MATCHED SET	50423	TYP SET
R10	12-08860-1A	RFF 323 ATTEN MATCHED SET	50423	TYP SET
R..11	12-12252-0A	RFF 348.0 250 MW F+-1%	16299	CGW RN55D 3480 F
S1	25-10166-1G	SWC RANGE SWC MODIFIED	50423	

OUTPUT ATTENUATOR AND DETECTOR

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
CR..5	05-10061-1B	"DHF DIODE MATCHED PAIR"	16068	INT DIODE CORP.
CR..6	05-10061-1B	"DHF DIODE MATCHED PAIR"	16068	INT DIODE CORP.
C25	07-02441-0A	CVC 9.0-35PF200.0 V	72982	ERIE 538-002-D9-35
C26	07-08116-0A	CCT 15 PF 500 V J 5%	95121	QUALITY COMPONENTS
C27	07-02441-0A	CVC 9.0-35PF200.0 V	72982	ERIE 538-002-D9-35
C35	07-07818-0A	CEA 6.8UF 6 V K 10%	56289	SPRAGUE 150D685X9006A2
C36	07-07818-0A	CEA 6.8UF 6 V K 10%	56289	SPRAGUE 150D685X9006A2
C38	07-02583-0A	CMB 1.0NF 500.0 V	1121	ALLEN-BRADLEY TYPE SRUA
C39	07-02583-0A	CMB 1.0NF 500.0 V	1121	ALLEN-BRADLEY TYPE SRUA
C43	07-07840-0A	CEA 470. NF 35 V K 10%	56289	SPRAGUE 150D474X9035A2
C44	07-07840-0A	CEA 470. NF 35 V K 10%	56289	SPRAGUE 150D474X9035A2
R110	12-12384-0A	RFF 7.50K 250.0MW F+- 1%	16299	CGW RN55D 7501 F
R35	12-12220-0A	RFF 162.0 250.0MW F+- 1 %	16299	CGW RN55D 1620 F
R36	09-10130-0A	RVC 25.0 K M TRIMPT	11236	CTS X201
R37	12-08858-1A	RFF	50423	TYP SET
R38	12-08858-1A	RFF	50423	TYP SET
R39	12-08858-1A	RFF	50423	TYP SET
R40	12-08858-1A	RFF	50423	TYP SET
R41	12-08858-1A	RFF	50423	TYP SET
R42	12-08858-1A	RFF	50423	TYP SET
R45	12-12502-0A	RFF 105.0 K 250.0MW F+- 1%	16299	CGW RN55D 1053 F
R46	12-12502-0A	RFF 105.0 K 250.0MW F+- 1%	16299	CGW RN55D 1053 F
R47	12-12502-0A	RFF 105.0 K 250.0MW F+- 1%	16299	CGW RN55D 1053 F
R48	12-12502-0A	RFF 105.0 K 250.0MW F+- 1%	16299	CGW RN55D 1053 F

RF AMPLIFIER

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C..10	07-10332-1A	CEA 220.0UF 25.0 V	50423	STOLAROFF TA156220673
C..11	07-02592-0A	CCD 1.0NF 1.0KVK+-10%	84171	ARCO TYPE CCD-102
C..12	07-09566-0A	CET 68.0UF 20.0 VK 10%	56289	SPG TYP 150D686X902032
C..13	07-10238-0A	CTF 150.0UF 15.0VK	56289	SPRAGUE 196D157X9015MA3
C..14	07-10238-0A	CTF 150.0UF 15.0VK	56289	SPRAGUE 196D157X9015MA3
C..15	07-02785-0A	CET 6.8UF 35 V K 10%	56289	SPRAGUE 150D685X9035B2
C..16	07-02441-0A	CVC 9.0-35PF200.0 V	72982	ERIE 538-002-D9-35
C..17	07-02535-0A	CCD 10.0FF	9023	GMC C-D TYPE BYA-6S1
C..18	07-02240-0A	CMM 20 PF 500 V J 5%	84171	ARCO TYPE CM15-C-200-J
C..19	07-10237-0A	CTF 100.0UF 20.0 VK	56289	SPRAGUE 196D107X9020MA3
C..20	07-02592-0A	CCD 1.0NF 1.0KVK+-10%	84171	ARCO TYPE CCD-102
C..45	07-07820-0A	CEA 470.0 25.0 VK+-10%	73445	ET471X025A01 AMPEREX
CR..1	05-07920-0A	DGP 1N4148 75 10M	7263	FCH SI D035
CR..2	10-10081-0A	TRQ 2N3638A PNP	7263	FAIRCHILD
CR..3	05-07920-0A	DGP 1N4148 75 10M	7263	FCH SI D035
CR..4	10-10081-0A	TRQ 2N3638A PNP	7263	FAIRCHILD
L...1	03-06274-1B	CLF INDUCTOR	50423	
Q...1	10-10137-1A	TRQ 2N4221A & RESISTOR	50423	BLI SEL PER 99-10072-5A
Q...2	10-08055-0A	TRQ 2N918 PNP 1 15 PTO-18	7263	FCH .300 900M 20
Q...3	10-08055-0A	TRQ 2N918 PNP 1 15 PTO-18	7263	FCH .300 900M 20
R..15	12-12300-0A	RFF 1.0 K 250 MW F+-1%	16299	CGW RN55D 1001 F
R..16	12-12368-0A	RFF 5.11K 250.0MW F+- 1%	16299	CGW RN55D 5111 F
R..18	12-12140-0A	RFF 26.1 250.0MW F+- 1%	16299	CGW RN55D 26R1 F
R..19	12-12528-0A	RFF 196.0 K 250 MW F+-1%	16299	CGW RN55D 1963 F
R..21	12-12100-0A	RFF 10.0 250.0MW F+- 1%	16299	CGW RN55D 10R0 F
R..22	12-12328-0A	RFF 1.96K 250.0MW F+- 1%	16299	CGW RN55D 1961 F
R..23	12-12300-0A	RFF 1.0 K 250 MW F+-1%	16299	CGW RN55D 1001 F
R..24	12-12148-0A	RFF 31.6 250.0MW F+- 1%	16299	CGW RN55D 31R6 F
R..25	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	16299	CGW RN55D 1002 F
R..26	12-12300-0A	RFF 1.0 K 250 MW F+-1%	16299	CGW RN55D 1001 F
R..27	12-12188-0A	RFF 82.5 250.0MW F+- 1%	16299	CGW RN55D 82R5 F
R..50	12-12188-0A	RFF 82.5 250.0MW F+- 1%	16299	CGW RN55D 82R5 F
R..93	12-12368-0A	RFF 5.11K 250.0MW F+- 1%	16299	CGW RN55D 5111 F

POWER SUPPLY AND DC AMPLIFIER

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C..62	07-07836-0A	CEA 100 UF 64 V K -10+50%	73445	AMPEREX C437AR/H100
C.101	07-10575-0A	CEA 220UF 10.0V	0	ST.TR EK220/10
C.102	07-10575-0A	CEA 220UF 10.0V	0	ST.TR EK220/10
C.103	07-10575-0A	CEA 220UF 10.0V	0	ST.TR EK220/10
C.104	07-10339-0A	CBM 100.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A100K
C.105	07-10339-0A	CBM 100.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A100K
C.106	07-10339-0A	CBM 100.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A100K
C.107	07-10339-0A	CBM 100.0NF 100.0 V +-10%	80031	MEPCO C280MCH/A100K
C.108	07-10496-0A	CCD 100.0NF 50.0 V	0	CAPAR CCD .1UFYFZ 50V
C.109	07-10496-0A	CCD 100.0NF 50.0 V	0	CAPAR CCD .1UFYFZ 50V
C.110	07-10487-0A	CBM 330.0NF 100.0 VK	80031	MEPCO C28MCH/A330K
C.111	07-10487-0A	CBM 330.0NF 100.0 VK	80031	MEPCO C28MCH/A330K
CR..9	05-08058-0A	DGP 1N4006 400 1A	15238	ITT SI D046
CR.10	05-08058-0A	DGP 1N4006 400 1A	15238	ITT SI D046
CR.11	05-08058-0A	DGP 1N4006 400 1A	15238	ITT SI D046
CR.12	05-08058-0A	DGP 1N4006 400 1A	15238	ITT SI D046
CR100	05-07920-0A	DGP 1N4148 75 10M	7263	FCH SI D035
R.102	12-13171-0A	RFF 1.0 M 500.0MW F 50PPM	80031	MEPCO RN60C MEPCO ONLY
R.103	12-13171-0A	RFF 1.0 M 500.0MW F 50PPM	80031	MEPCO RN60C MEPCO ONLY
R.104	12-12100-0A	RFF 10.0 250.0MW F+- 1%	16299	CGW RN55D 10R0 F
R.105	12-12100-0A	RFF 10.0 250.0MW F+- 1%	16299	CGW RN55D 10R0 F

POWER SUPPLY AND DC AMPLIFIER (Continued)

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R,106	12-12552-0A	RFF 348.0 K 500 MW F+-1%	16299	CGW RN60D 3483 F
R,107	12-12552-0A	RFF 348.0 K 500 MW F+-1%	16299	CGW RN60D 3483 F
R,108	12-13171-0A	RFF 1.0 M 500.0MW F 50PPM	80031	MEPCO RN60C MEPCO ONLY
R,109	09-10003-0A	RVC 100.0 K 0.5 W K+-10%	73138	HEL TYP 72PM
R,111	12-13171-0A	RFF 1.0 M 500.0MW F 50PPM	80031	MEPCO RN60C MEPCO ONLY
R,112	12-12432-0A	RFF 21.5 K 250.0MW F+- 1%	16299	CGW RN55D 2152 F
R,113	12-12354-0A	RFF 3.65K 250.0MW F+- 1%	16299	CGW RN55D 3651 F
R,114	09-10001-0A	RVC 500.0 0.5 W K	73138	HEL TYP 72PM
R,115	12-12344-0A	RFF 2.87K 205.0MW F+- 1%	16299	CGW RN55D 2871 F
R,116	12-12344-0A	RFF 2.87K 205.0MW F+- 1%	16299	CGW RN55D 2871 F
R,117	12-12316-0A	RFF 1.47K 250 MW F+-1%	16299	CGW RN55D 1471 F
R,118	12-12364-0A	RFF 4.64K 250.0MW F+- 1%	16299	CGW RN55D 4641 F
R,120	09-10001-0A	RVC 500.0 0.5 W K	73138	HEL TYP 72PM
R,121	12-13278-0A	RFC 1.87K 250MW F 100PPM	0	MEPCO RN55D MEPCO ONLY
U,100	24-10358-0A	ICP ICC7660 VOLTAGE CONVERT	0	INTERSIL ICL7660CPA
U,101	24-10359-0A	ICP ICL7650 CHOPPER OP-AMP	0	INTERSIL ICL7650CPD
U,102	24-10359-0A	ICP ICL7650 CHOPPER OP-AMP	0	INTERSIL ICL7650CPD
U,103	24-10212-0A	ICP CA3140E FET OP AM MINDIP	86684	RCA CA3140G FET OPAMP MINIDIP

POWER SUPPLY (BATTERY) 06/20

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
CR,14	05-07910-0A	DZP 1N9578 6.8 18M	27832	FCH SI D07 ZENER DIODE
CR,16	05-08058-0A	DGP 1N4006 400 1A	15238	ITT SI D046
Q,,,9	10-07929-0A	TRQ 2N 555 PNP 1 30 M11-01	4713	MOT 10 55K 15
R,,76	12-12328-0A	RFF 1.96K 250.0MW F+- 1%	16299	CGW RN55D 1961 F
R,,77	12-12140-0A	RFF 26.1 250.0MW F+- 1%	16299	CGW RN55D 26R1 F
R,,78	12-12140-0A	RFF 26.1 250.0MW F+- 1%	16299	CGW RN55D 26R1 F
R,,79	12-12164-0A	RFF 46.4 250.0MW F+- 1%	16299	CGW RN55D 46R4 F

POWER SUPPLY (AC) 07/21

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C,,63	07-02096-0A	CEA 50, UF 15 V T	56289	SPRAGUE TYPE 30D170A1
C,100	07-07847-0A	CEA 10 UF 16 V T	73445	AMPEREX C426AR/E10
CR,13	05-07910-0A	DZP 1N9578 6.8 18M	27832	FCH SI D07 ZENER DIODE
R,,76	12-13186-0A	RWW 430.0 3.0 W J	91637	DALE CW-2A 430 OHM 5% O/E
U,,,1	24-10051-0A	ICP 78M12C 12 VOLT REG 1/2A	7263	FAIRCHILD UA78M12UC OR EQUIV

TIME CONSTANT SWITCH

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C37	07-10205-0A	CYM 1.8PF 100.0 VM	14752	ELEC-CUB 230DI8185 OR EQV
C40	07-10205-0A	CYM 1.8PF 100.0 VM	14752	ELEC-CUB 230DI8185 OR EQV
C41	07-10326-0A	CMD 470.0NF 80.0VK 10%	56289	SPRAGUE 192P4749R8
C42	07-10326-0A	CMD 470.0NF 80.0VK 10%	56289	SPRAGUE 192P4749R8
C67	07-09569-0A	CET 22 UF 15 V K 10%	56289	SPG TYP 150D226X901582
C68	07-09569-0A	CET 22 UF 15 V K 10%	56289	SPG TYP 150D226X901582
S2	25-10161-1A	SWC 323 TIME CONSTANT	76854	OAK EFFECTIVE SER.

FUNCTION SWITCH

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
R100	12-12140-0A	RFF 26.1 250.0MW F+- 1%	16299	CGW RN55D 26R1 F
R101	12-12220-0A	RFF 162.0 250.0MW F+- 1 5	16299	CGW RN55D 1620 F
R66	12-12472-0A	RFF 56.2 K 250.0MW F+- 1%	16299	CGW RN55D 5622 F
S3	25-10162-1A	SWC 323 MODE AC & BAT	50423	BLI MOD FROM 25100141A

SUB-CHASSIS 06/20

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
B1	85-08603-0A	BNC 12V, 6V TAP, 1.2AM	31741	NICAD TYPE MP, 402T MB400642
C..67	07-02264-0A	CMD 500 PF 300 V J 5%	84171	ARCO TYPE DM-15-501J
R..94	12-12154-0A	RFF 36.5 250.0MW F+- 1%	16299	CGW RN55D 36R5 F
R..94	12-12165-0A	RFF 47.5 250.0MW F+- 1%	16299	CGW RN55D 47R5 F
R..95	12-12117-0A	RFF 15.0 250.0MW F+- 1%	16299	CGW RN55D 15R0 F
T1	20-06262-10	TRX 323 POWER	50423	MODEL 323

SUB-CHASSIS 07/21

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
C..67	07-02264-0A	CMD 500 PF 300 V J 5%	84171	ARCO TYPE DM-15-501J
R .94	12-12154-0A	RFF 36.5 250.0MW F+- 1%	16299	CGW RN55D 36R5 F
R .94	12-12165-0A	RFF 47.5 250.0MW F+- 1%	16299	CGW RN55D 47R5 F
R..95	12-12117-0A	RFF 15.0 250.0MW F+- 1%	16299	CGW RN55D 15R0 F
T. 1	20-06262-10	TRX 323 POWER	50423	MODEL 323

FINAL 06/07

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
M1	18-06047-1L	MTR SCALE 5 1/2 CASE	50423	

FINAL 20/21

SCHEMATIC REF	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR PART NUMBER
M...1	18-06046-1N	MTR SCALE 5 1/2 CASE	50423	

APPENDIX B

ADDENDUM

to

INSTRUCTION MANUAL

for

323 SERIES

TRUE RMS VOLTMETERS

SCHEMATIC DIAGRAMS AND PARTS LISTS

for

SERIAL NO. 101-2194

BALLANTINE LABORATORIES, INC.

P.O. BOX 97, BOONTON, N.J. 07005

90100755A

August 1975

REPLACEMENT PARTS LIST

NOTE: This replacement parts list applies only to the Model 323.

B. L. Part No.	Circuit Symbol	Capacitors	Manufacturer
8138	C1	.15 μF, 600 V, 10%, Type 6DP-5-154	Arco
2454	C2	0.7-3.0 pF, 350 V, Type 535-000	Erie
2282	C3	330 pF, 5%, 500 V, Type 653-015	Erie
2454	C4	0.7-3.0 pF, 350 V, Type 535-000	Erie
2282	C5	330 pF, 5%, 500 V, Type 653-015	Erie
2446	C6	5.5-18 pF, 350 V, Type 538-002 NPO	Erie
9376	C10	250 μF, 15 V, −10% +100% MTV250DE15	Mallory
2592	C11	1000 pF, 10%, 1000 V, Type CCD-102	Arco
9566	C12	68 μF, 20 V, 10%, Type CS13BE686K	Sprague
2085	C13	150 μF, 6 V, −10% +75%, Type TE1103	Sprague
7843	C14	75 μF, 15 V, −10% +50%, Type TE1161	Sprague
2785	C15	6.8 μF, 35 V, 10%, Type CS13BF685K	Sprague
9151	C16	8-50 pF, 500 V, Type 557-091	Erie
2535	C17	0.01 μF, Type BYA-651	Cornell-Dubilier
2240	C18	20 pF, ±5%, 500 V, Type CM-15	Arco
9568	C19	100 μF, 20 V, 10%, Type CS13BE107K	Sprague
2592	C20	1000 pF, 10%, 1000 V, Type CCD-102	Arco
2441	C25	9-35 pF, 500 V, Type 538-002	Erie
8116	C26	15 pF, 5%, 500 V, Type QC	Quality Components
2441	C27	9-35 pF, 500 V, Type 538-002	Erie
9569	C35	22 μF, 15 V, 10%, Type CS13BD226K	Sprague
9569	C36	22 μF, 15 V, 10%, Type CS13BD226K	Sprague
7819	C37	1.8 μF, ±10%, 20 V, Type 150D185X9020A0	Sprague
2583	C38	1000 pF, 500 V, Type SB4A	Allen-Bradley
2583	C39	1000 pF, 500 V, Type SB4A	Allen-Bradley
7819	C40	1.8 μF, ±10%, 20 V, Type 150D185X9020A0	Sprague
7840	C41	0.47 μF, ±10%, 35 V, Type 150D474X9035A0	Sprague
7840	C42	0.47 μF, ±10%, 35 V, Type 150D474X9035A0	Sprague
7840	C43	0.47 μF, ±10%, 35 V, Type 150D474X9035A0	Sprague
7840	C44	0.47 μF, ±10%, 35 V, Type 150D474X9035A0	Sprague
7820	C45	400 μF, −10% +50%, 16 V, Type C437AR/E400	Amperex
or 7821	C45	400 μF, −10% +75%, 15 V, Type 34D407G015GE2	Sprague
2394	C46	0.1 μF, 5%, 200 V, Type 192P	Sprague
7820	C47	400 μF, −10% +50%, 16 V, Type C437AR/E400	Amperex
or 7821	C47	400 μF, −10% +75%, 15 V, Type 34D407G015GE2	Sprague
2593	C48	50 pF, 10%, 1000 V, Type CCD-500	Arco
2592	C49	1000 pF, 10%, 1000 V, Type CCD-102	Arco
8118	C50	0.0068 μF, 5%, 200 V, Type 192P	Sprague
7814	C51	1 μF, −10% +75%, 12 V, Type 30D	Sprague
7814	C52	1 μF, −10% +75%, 12 V, Type 30D	Sprague
7843	C53	75 μF, −10%, +50%, 15 V, Type 30D756F015CC4	Sprague
2592	C54	1000 pF, 10%, 1000 V, Type CCD-102	Arco
7816	C55	47 μF, 10%, 20 V, Type 150D476X9020R2	Sprague

*In some instruments the component listed may not be used at all or its value may differ from the value shown.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323.

B. L. Part No.	Circuit Symbol	Resistors	Manufacturer
8861	R45	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
8861	R46	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
8861	R47	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
8861	R48	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
1083	R50	82 Ω, 5%, Type EB	Allen-Bradley
1098	R51	120 Ω, 5%, Type EB	Allen-Bradley
1231	R52	200 Ω, 5%, Type CB	Allen-Bradley
1320	R53	20 kΩ, 1%, Type CPX-½	Aerovox
2685	R54	10 Ω, 1%, Type CPX-½	Aerovox
1014	R55	510 kΩ, 5%, Type EB	Allen-Bradley
1040	R56	20 kΩ, 5%, Type EB	Allen-Bradley
6867	R57	10 Ω, ±10%, Type 115	CTS
1021	R58	270 kΩ, 5%, Type EB	Allen-Bradley
1017	R59	390 kΩ, 5%, Type EB	Allen-Bradley
1358	R60*	60 Ω, 1%, Type CPX-½	Aerovox
1065	R61	200 Ω, 5%, Type EB	Allen-Bradley
8455	R62	3.5 Ω, 1%, Type M61	Mepco
1036	R63	33 kΩ, 5%, Type EB	Allen-Bradley
6854	R64	10 kΩ, ±10%, Type 115	CTS
1019	R65	330 kΩ, 5%, Type EB	Allen-Bradley
8852	R66	54.5 kΩ, 1%, Type MF6C	Electra
2732	R67	1.58 kΩ, 1%, Type CPX-½	Aerovox
6861	R68	200 Ω, ±10%, Type 115	CTS
9251	R69	10.4 MΩ, 1%, Type N4	Constanta
9251	R70	10.4 MΩ, 1%, Type N4	Constanta
1054	R76	2 kΩ, 5%, Type EB	Allen-Bradley
7249	R77	48.7 Ω, 2%, Type C32	Corning
6867	R78	10 Ω, ±10%, Type 115	CTS
1097	R79	47 Ω, 5%, Type EB	Allen-Bradley
6854	R85	10 kΩ, ±10%, Type 115	CTS
6854	R86	10 kΩ, ±10%, Type 115	CTS
7261	R87	45.6 kΩ, 1%, Type MF7C	Electra
7261	R88	45.6 kΩ, 1%, Type MF7C	Electra
1111	R89	1.8 kΩ, 5%, Type EB	Allen-Bradley
1111	R90	1.8 kΩ, 5%, Type EB	Allen-Bradley
1098	R91	120 Ω, 5%, Type EB	Allen-Bradley
1098	R92	120 Ω, 5%, Type EB	Allen-Bradley

*In some instruments the component listed may not be used at all or its value may differ from the value shown.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323.

B. L. Part No.	Circuit Symbol	Capacitors	Manufacturer
2592	C56	1000 pF, 10%, 1000 V, Type CCD-102	Arco
2394	C57	0.1 μF, 5%, 200 V, Type 192P	Sprague
2592	C58	1000 pF, 10%, 1000 V, Type CCD-102	Arco
7836	C62	100 μF, −10% +50%, 64 V, Type C437AR/H100	Amperex
or 7837	C62	100 μF, −10% +75%, 50 V, Type 30D107G050DH4	Sprague
2354	C65	0.15 μF, 10%, 200 V, Type 192P	Sprague
2354	C66	0.15 μF, 10%, 200 V, Type 192P	Sprague
		Resistors	
6070	R1	1 MΩ, 1%, Type MF6C	Electra
6070	R2	1 MΩ, 1%, Type MF6C	Electra
1672	R3	100 Ω, 1%, Type N-20	Corning
6070	R4[1]	1 MΩ, 1%, Type MF6C	Electra
6070	R5[1]	1 MΩ, 1%, Type MF6C	Electra
6076	R6[1]	20.2 kΩ, 1%, Type MF5C	Electra
6070	R7[2]	1 MΩ, 1%, Type MF6C	Electra
6070	R8[2]	1 MΩ, 1%, Type MF6C	Electra
6076	R9[2]	20.2 kΩ, 1%, Type MF5C	Electra
6078	R10[2]	202 Ω, 1%, Type MF5C	Electra
1057	R15	1 kΩ, 5%, Type EB	Allen-Bradley
1327	R16	5 kΩ, 1%, Type CPX-½	Aerovox
1338	R17*	1 kΩ, 1%, Type CPX-½	Aerovox
2706	R18	25 Ω, 1%, Type CPX-½	Aerovox
1305	R19	200 kΩ, 1%, Type CPX-½	Aerovox
1117	R21	10 Ω, 5%, Type EB	Allen-Bradley
1054	R22	2 kΩ, 5%, Type EB	Allen-Bradley
1338	R23	1 kΩ, 1%, Type CPX-½	Aerovox
1074	R24	30 Ω, 5%, Type EB	Allen-Bradley
1044	R25	10 kΩ, 5%, Type EB	Allen-Bradley
1338	R26	1 kΩ, 1%, Type CPX-½	Aerovox
1083	R27	82 Ω, 5%, Type EB	Allen-Bradley
1066	R35	160 Ω, 5%, Type EB	Allen-Bradley
1954	R36	10 kΩ, ±20%, Type X201	CTS
6073	R37[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6073	R38[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6073	R39[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6074	R40[3]	92.5 Ω, 1%, Type MF5C	Ballantine
6074	R41[3]	92.5 Ω, 1%, Type MF5C	Ballantine
6075	R42[3]	63.25 Ω, 1%, Type MF5C	Ballantine

In some instruments the component listed may not be used at all or its value may differ from the value shown.

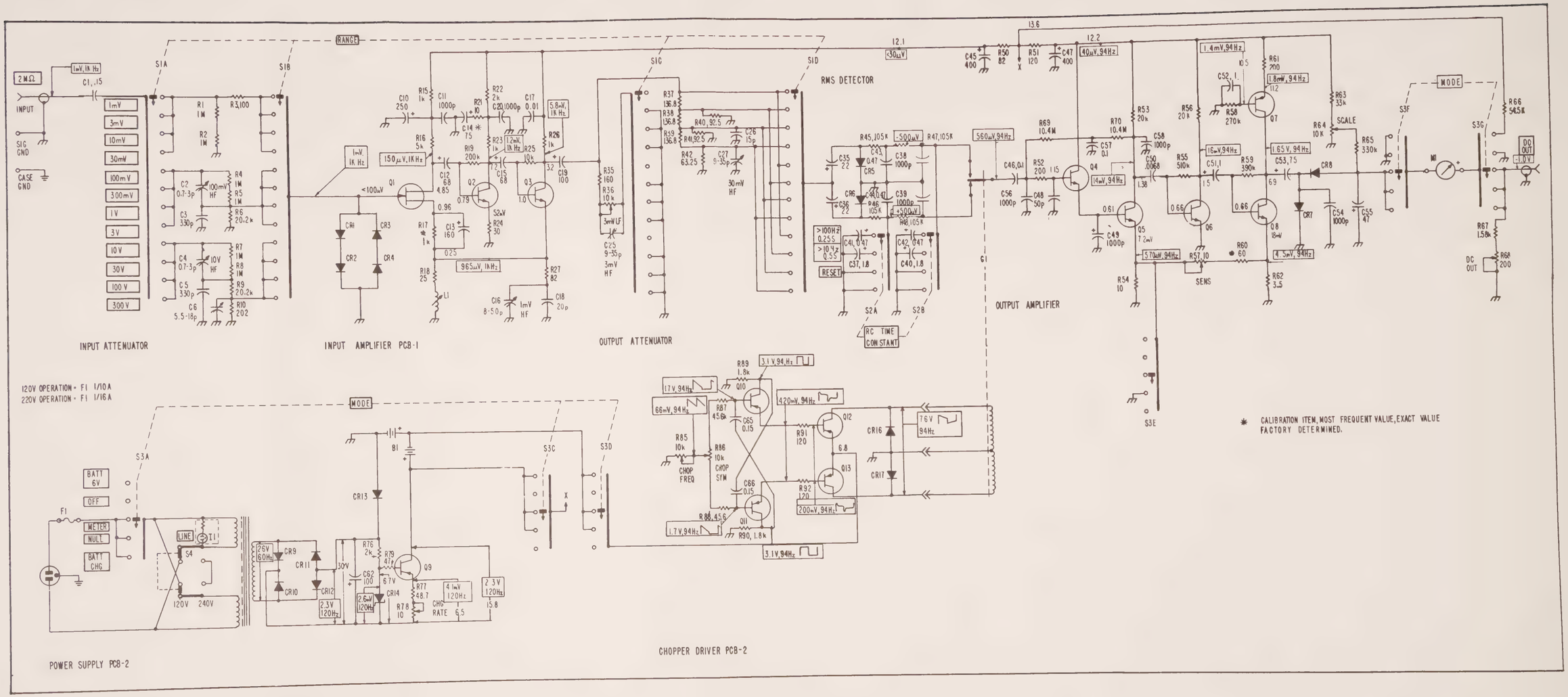
[1] Resistors R4, R5, R6 are part of a matched set and must be purchased as Set No. 8859.
[2] Resistors R7, R8, R9, R10 are part of a matched set and must be purchased as Set No. 8860.
[3] Resistors R37, R38, R39, R40, R41, R42 are part of a matched set and must be purchased as Set No. 8858.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323.

B. L. Part No.	Circuit Symbol	Other Components	Manufacturer
8603	B1	Battery, 12 V, 6 V Tap, 1.2 AH, Type MP	Ballantine
7920	CR1	Diode, Type 1N4148	General Electric
7920	CR2	Diode, Type 1N4148	General Electric
7920	CR3	Diode, Type 1N4148	General Electric
7920	CR4	Diode, Type 1N4148	General Electric
7924	CR5	Diode, Unitunnel, Type HU5A, Selected	Ballantine
7924	CR6	Diode, Unitunnel, Type HU5A, Selected	Ballantine
7920	CR7	Diode, Type 1N4148	General Electric
7920	CR8	Diode, Type 1N4148	General Electric
7921	CR9	Rectifier, Silicon, Type 36591	Ballantine
7921	CR10	Rectifier, Silicon, Type 36591	Ballantine
7921	CR11	Rectifier, Silicon, Type 36591	Ballantine
7921	CR12	Rectifier, Silicon, Type 36591	Ballantine
7921	CR13	Rectifier, Silicon, Type 36591	Ballantine
7910	CR14	Diode, Zener, Type 1N957B, ±5%, 6.8 V	Hughes
7920	CR16	Diode, Type 1N4148	General Electric
7920	CR17	Diode, Type 1N4148	General Electric
2810	F1	Fuse, 1/10 A, Slo-Blo, for 120 V operation, Type 313.100, 3AG	Littelfuse
or 2806	F1	Fuse, 1/16 A, Slo-Blo, for 240 V operation, Type 313.062, 3AG	Littelfuse
9700	G1	Chopper, 6.3 V, Type C1417-49	Bristol
3490	I1	Pilot Light, Type 2110A1	Industrial Devices
6267	L1	Inductor, Special	Ballantine
7933	Q1	Transistor, Type 2N4221A, Selected*	Ballantine
7926	Q2	Transistor, Type 2N3563, Selected*	Ballantine
7926	Q3	Transistor, Type 2N3563, Selected*	Ballantine
7938	Q4	Transistor, Type A322, Selected*	Ballantine
7938	Q5	Transistor, Type A322, Selected*	Ballantine
7938	Q6	Transistor, Type A322, Selected*	Ballantine
7927	Q7	Transistor, Type 2N3638, Selected*	Ballantine
7938	Q8	Transistor, Type A322, Selected*	Ballantine
7929	Q9	Transistor, Type 2N555	Motorola
7927	Q10	Transistor, Type 2N3638	Fairchild
7927	Q11	Transistor, Type 2N3638	Fairchild
7927	Q12	Transistor, Type 2N3638	Fairchild
7927	Q13	Transistor, Type 2N3638	Fairchild
6018	M1	Microammeter, Logarithmic Type, 60 - 600 μA	Ballantine
7765	S1	Switch, Range, Special	Ballantine
7766	S2	Switch, Time Constant, Special	Ballantine
7764	S3	Switch, Mode, Special	Ballantine
7775	S4	Switch, Slide, Type G126-PC	Continental Wirt
6262	T1	Transformer, Power, Special	Ballantine
4156	—	AC Power Cord	Ballantine

*If replacement of selected transistors is necessary, order from Ballantine Laboratories giving type, symbol, designation (Q1, Q2, etc.) and color code (center dot, side dot, etc.) if any.



CAPACITORS: NOT MARKED — MICROFARADS (10^{-6}F)
P — PICOFARADS (10^{-12}F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3}Ω)
M — MEGOHMS (10^{6}Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3}V)

ALL DC, AC VOLTAGES MEASURED WITH REFERENCE TO SIGNAL GROUND UNLESS OTHERWISE INDICATED

Fig. B-1. Schematic and Parts List, Model 323 (Serial No. 101-2194)

REPLACEMENT PARTS LIST

NOTE: This replacement parts list applies only to the Model 323-01.

B. L. Part No.	Circuit Symbol	Capacitors	Manufacturer
8138	C1	.15 μF, 600 V, 10%, Type 6DP-S-154	Arco
2454	C2	0.7-3.0 pF, 350 V, Type 535-000	Erie
2282	C3	330 pF, 5%, 500 V, Type 653-015	Erie
2454	C4	0.7-3.0 pF, 350 V, Type 535-000	Erie
2282	C5	330 pF, 5%, 500 V, Type 653-015	Erie
2446	C6	5.5-18 pF, 350 V, Type 538-002 NPO	Erie
9376	C10	250 μF, 15 V, −10% +100% MTV250DE15	Mallory
2592	C11	1000 pF, 10%, 1000 V, Type CCD-102	Arco
9566	C12	68 μF, 20 V, 10%, Type CS13BE686K	Sprague
2085	C13	150 μF, 6 V, −10% +75%, Type TE1103	Sprague
7843	C14	75 μF, 15 V, −10% +50%, Type TE1161	Sprague
2785	C15	6.8 μF, 35 V, 10%, Type CS13BF685K	Sprague
9151	C16	8-50 pF, 350 V, Type 557-091	Erie
2535	C17	0.01 μF, Type BYA-6S1	Cornell-Dubilier
2240	C18	20 pF, ±5%, 500 V, Type CM-15	Arco
9568	C19	100 μF, 20 V, 10%, Type CS13BE107K	Sprague
2592	C20	1000 pF, 10%, 1000 V, Type CCD-102	Arco
2441	C25	9-35 pF, 500 V, Type 538-002	Erie
8116	C26	15 pF, 5%, 500 V, Type QC	Quality Components
2441	C27	9-35 pF, 500 V, Type 538-002	Erie
9569	C35	22 μF, 15 V, 10%, Type CS13BD226K	Sprague
9569	C36	22 μF, 15 V, 10%, Type CS13BD226K	Sprague
7819	C37	1.8 μF, ±10%, 20 V, Type 150D185X9020D0	Sprague
2583	C38	1000 pF, 500 V, Type SB4A	Allen-Bradley
2583	C39	1000 pF, 500 V, Type SB4A	Allen-Bradley
7819	C40	1.8 μF, ±10%, 20 V, Type 150D185X9020A0	Sprague
7840	*C41	0.47 μF, ±10%, 35 V, Type 150D474X9035A0	Sprague
7840	C42	0.47 μF, ±10%, 35 V, Type 150D474X9035A0	Sprague
7840	C43	0.47 μF, ±10%, 35 V, Type 150D474X9035A0	Sprague
7840	C44	0.47 μF, ±10%, 35 V, Type 150D474X9035A0	Sprague
7820	C45	400 μF, −10% +50%, 16 V, Type C437AR/E400	Amperex
or 7821	C45	400 μF, −10% +75%, 15 V, Type 34D407G015GE2	Sprague
2394	C46	0.1 μF, 5%, 200 V, Type 192P	Sprague
7820	C47	400 μF, −10% +50%, 16 V, Type C437AR/E400	Amperex
or 7821	C47	400 μF, −10% +75%, 15 V, Type 34D407G015GE2	Sprague
2593	C48	50 pF, 10%, 1000 V, Type CCD-500	Arco
2592	C49	1000 pF, 10%, 1000 V, Type CCD-102	Arco
8118	C50	0.0068 μF, 5%, 200 V, Type 192P	Sprague
7814	C51	1 μF, −10% +75%, 12 V, Type 30D	Sprague
7814	C52	1 μF, −10% +75%, 12 V, Type 30D	Sprague
7843	C53	75 μF, −10%, +50%, 15 V, Type 30D756F015CC4	Sprague
2592	C54	1000 pF, 10%, 1000 V, Type CCD-102	Arco
7816	C55	47 μF, 10%, 20 V, Type 150D476X9020R2	Sprague
2592	C56	1000 pF, 10%, 1000 V, Type CCD-102	Arco

In some instruments the component listed may not be used at all or its value may differ from the value shown.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-01.

B. L. Part No.	Circuit Symbol	Resistors	Manufacturer
6074	R41[3]	92.5 Ω, 1%, Type MF5C	Ballantine
6075	R42[3]	63.25 Ω, 1%, Type MF5C	Ballantine
8861	R45	105 kΩ, 1%, Type MF5C, CHAR D	Electra
8861	R46	105 kΩ, 1%, Type MF5C, CHAR D	Electra
8861	R47	105 kΩ, 1%, Type MF5C, CHAR D	Electra
8861	R48	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
1083	R50	82 Ω, 5%, Type EB	Allen-Bradley
1098	R51	120 Ω, 5%, Type EB	Allen-Bradley
1231	R52	200 Ω, 5%, Type CB	Allen-Bradley
1320	R53	20 kΩ, 1%, Type CPX-½	Aerovox
2685	R54	10 Ω, 1%, Type CPX-½	Aerovox
1014	R55	510 kΩ, 5%, Type EB	Allen-Bradley
1040	R56	20 kΩ, 5%, Type EB	Allen-Bradley
6867	R57	10 Ω, ±10%, Type 115	CTS
1021	R58	270 kΩ, 5%, Type EB	Allen-Bradley
1017	R59	390 kΩ, 5%, Type EB	Allen-Bradley
1358	R60*	60 Ω, 1%, Type CPX-½	Aerovox
1065	R61	200 Ω, 5%, Type EB	Allen-Bradley
8455	R62	3.5 Ω, 1%, Type M61	Mepco
1036	R63	33 kΩ, 5%, Type EB	Allen-Bradley
6854	R64	10 kΩ, ±10%, Type 115	CTS
1019	R65	330 kΩ, 5%, Type EB	Allen-Bradley
2732	R67	1.58 kΩ, 1%, Type CPX-½	Aerovox
6861	R68	200 Ω, ±10%, Type 115	CTS
9251	R69	10.4 MΩ, 1%, Type N4	Constanta
9251	R70	10.4 MΩ, 1%, Type N4	Constanta
8026	R76	430 Ω, 5%, Type PW3	IRC
1094	R77	2.4 kΩ, 5%, Type EB	Allen-Bradley
1094	R78	2.4 kΩ, 5%, Type EB	Allen-Bradley
6854	R85	10 kΩ, ±10%, Type 115	CTS
6854	R86	10 kΩ, ±10%, Type 115	CTS
7261	R87	45.6 kΩ, 1%, Type MF7C	Electra
7261	R88	45.6 kΩ, 1%, Type MF7C	Electra
1111	R89	1.8 kΩ, 5%, Type EB	Allen-Bradley
1111	R90	1.8 kΩ, 5%, Type EB	Allen-Bradley
1098	R91	120 Ω, 5%, Type EB	Allen-Bradley
1098	R92	120 Ω, 5%, Type EB	Allen-Bradley

* In some instruments the component listed may not be used at all or its value may differ from the value shown.

[3] Resistors R37, R38, R39, R40, R41, R42 are part of a matched set and must be purchased as Set No. 8858.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-01

B. L. Part No.	Circuit Symbol	Capacitors	Manufacturer
2394	C57	0.1 μF, 5%, 200 V, Type 192P	Sprague
2592	C58	1000 pF, 10%, 1000 V, Type CCD-102	Arco
7836	C62	100 μF, −10% +50%, 64 V, Type C437AR/H100	Amperex
or 7837	C62	100 μF, −10% +75%, 50 V, Type 30D107G050DH4	Sprague
2096	C63	50 μF, −10% +75%, 15 V, Type 30D	Sprague
7824	C64	250 μF, −10% +75%, 50 V, Type 39D257G050HE4	Sprague
or 7825	C64	250 μF, −10% +50%, 64 V, Type C437AR/H250	Amperex
2354	C65	0.15 μF, 10%, 200 V, Type 192P	Sprague
2354	C66	0.15 μF, 10%, 200 V, Type 192P	Sprague

		Resistors	
6070	R1	1 MΩ, 1%, Type MF6C	Electra
6070	R2	1 MΩ, 1%, Type MF6C	Electra
1672	R3	100 Ω, 1%, Type N-20	Corning
6070	R4[1]	1 MΩ, 1%, Type MF6C	Electra
6070	R5[1]	1 MΩ, 1%, Type MF6C	Electra
6076	R6[1]	20.2 kΩ, 1%, Type MF5C	Electra
6070	R7[2]	1 MΩ, 1%, Type MF6C	Electra
6070	R8[2]	1 MΩ, 1%, Type MF6C	Electra
6076	R9[2]	20.2 kΩ, 1%, Type MF5C	Electra
6078	R10[2]	202 Ω, 1%, Type MF5C	Electra
1057	R15	1 kΩ, 5%, Type EB	Allen-Bradley
1327	R16	5 kΩ, 1%, Type CPX-½	Aerovox
1338	R17*	1 kΩ, 1%, Type CPX-½	Aerovox
2706	R18	25 Ω, 1%, Type CPX-½	Aerovox
1305	R19	200 kΩ, 1%, Type CPX-½	Aerovox
1117	R21	10 Ω, 5%, Type EB	Allen-Bradley
1054	R22	2 kΩ, 5%, Type EB	Allen-Bradley
1338	R23	1 kΩ, 1%, Type CPX-½	Aerovox
1074	R24	30 Ω, 5%, Type EB	Allen-Bradley
1044	R25	10 kΩ, 5%, Type EB	Allen-Bradley
1338	R26	1 kΩ, 5%, Type CPX-½	Aerovox
1083	R27	82 Ω, 5%, Type EB	Allen-Bradley
1066	R35	160 Ω, 5%, Type EB	Allen-Bradley
1954	R36	10 kΩ, ±20%, Type X201	CTS
6073	R37[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6073	R38[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6073	R39[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6074	R40[3]	92.5 Ω, 1%, Type MF5C	Ballantine

In some instruments the component listed may not be used at all or its value may differ from the value shown.

[1] Resistors R4, R5, R6 are part of a matched set and must be purchased as Set No. 8859

[2] Resistors R7, R8, R9, R10 are part of a matched set and must be purchased as Set No. 8860

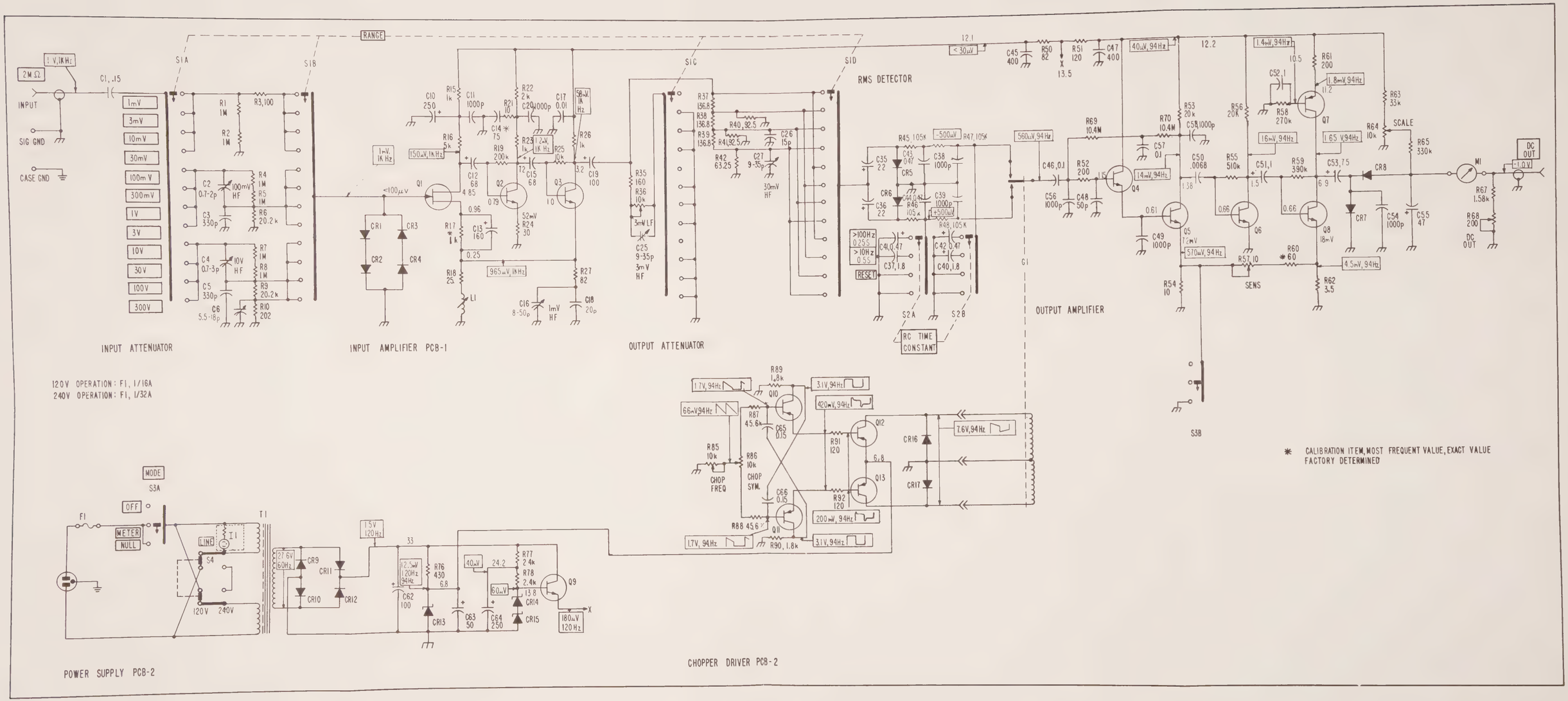
[3] Resistors R37, R38, R39, R40, R41, R42 are part of a matched set and must be purchased as Set No. 8858.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-01.

B. L. Part No.	Circuit Symbol	Other Components	Manufacturer
7920	CR1	Diode, Type 1N4148	General Electric
7920	CR2	Diode, Type 1N4148	General Electric
7920	CR3	Diode, Type 1N4148	General Electric
7920	CR4	Diode, Type 1N4148	General Electric
7924	CR5	Diode, Unitunnel, Type HU5A, Selected	Ballantine
7924	CR6	Diode, Unitunnel, Type HU5A, Selected	Ballantine
7920	CR7	Diode, Type 1N4148	General Electric
7920	CR8	Diode, Type 1N4148	General Electric
7921	CR9	Rectifier, Silicon, Type 36591	Ballantine
7921	CR10	Rectifier, Silicon, Type 36591	Ballantine
7921	CR11	Rectifier, Silicon, Type 36591	Ballantine
7921	CR12	Rectifier, Silicon, Type 36591	Ballantine
7910	CR13	Diode, Zener, Type 1N957B, ±5%, 6.8 V	Hughes
7910	CR14	Diode, Zener, Type 1N957B, ±5%, 6.8 V	Hughes
7910	CR15	Diode, Zener, Type 1N957B, ±5%, 6.8 V	Hughes
7920	CR16	Diode, Type 1N4148	General Electric
7920	CR17	Diode, Type 1N4148	General Electric
2806	F1	Fuse, 1/16 A, Slo-Blo, for 120 V operation, Type 313 062, 3AG	Littelfuse
or 2811	F1	Fuse, 1/32 A, Slo-Blo, for 240 V operation, Type 313 031, 3AG	Littelfuse
9700	G1	Chopper, 6.3 V, Type C1417-49	Bristol
3490	I1	Pilot Light, Type 2110A1	Industrial Devices
6267	L1	Inductor, Special	Ballantine
7933	Q1	Transistor, Type 2N4221A, Selected	Ballantine
7926	Q2	Transistor, Type 2N3563, Selected	Ballantine
7926	Q3	Transistor, Type 2N3563, Selected*	Ballantine
7938	Q4	Transistor, Type A322, Selected	Ballantine
7938	Q5	Transistor, Type A322, Selected*	Ballantine
7938	Q6	Transistor, Type A322, Selected	Ballantine
7927	Q7	Transistor, Type 2N3638, Selected*	Ballantine
7938	Q8	Transistor, Type A322, Selected	Ballantine
7930	Q9	Transistor, Type 2N3766	Motorola
7927	Q10	Transistor, Type 2N3638	Fairchild
7927	Q11	Transistor, Type 2N3638	Fairchild
7927	Q12	Transistor, Type 2N3638	Fairchild
7927	Q13	Transistor, Type 2N3638	Fairchild
6018	M1	Microammeter, Logarithmic Type, 60-600 μA	Ballantine
7765	S1	Switch, Range, Special	Ballantine
7766	S2	Switch, Time Constant, Special	Ballantine
7763	S3	Switch, Mode	Ballantine
7775	S4	Switch, Slide, Type G126-PC	Continental Wirt
6262	T1	Transformer, Power, Special	Ballantine
4156	—	AC Power Cord	Ballantine

*If replacement of selected transistors is necessary, order from Ballantine Laboratories giving type, symbol, designation (Q1, Q2, etc.) and color code (center dot, side dot, etc.) if any



CAPACITORS: NOT MARKED — MICROFARADS (10^{-6}F)
P — PICOFARADS (10^{-12}F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3}Ω)
M — MEGOHMS (10^{6}Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3}V)

* CALIBRATION ITEM, MOST FREQUENT VALUE, EXACT VALUE FACTORY DETERMINED

Fig. B-2. Schematic and Parts List, Model 323-01 (Serial No. 101-2194)

REPLACEMENT PARTS LIST

NOTE: This replacement parts list applies only to the Model 323-06.

B. L. Part No.	Circuit Symbol	Capacitors	Manufacturer
8138	C1	0.150 μF, 600 V. 10%	Sprague
2454	C2	0.7-3.0 pF, 350 V, Type 535-000	Erie
2282	C3	330 pF, 5%, 500 V, Type 653-015	Erie
2454	C4	0.7-3.0 pF, 350 V, Type 535-000	Erie
2282	C5	330 pF, 5%, 500 V, Type 653-015	Erie
2442	C6	2-8 pF, 200 V, Type 538-002 NPO	Erie
2096	C10	50 μF, −10% +75%, 15 V, Type 30D	Sprague
2592	C11	1000 pF, 10%, 1000 V, Type CCD-102	Arco
9376	C12	250 μF, 10%, 15 V. 10%	Sprague
2085	C13	150 μF, −10% +75%, 6 V, Type 30D	Sprague
7843	C14	75 μF, −10% +50%, 15 V, Type C426AR/G32	Amperex
2785	C15	6.8 μF, ±10%, 35 V, Type 150D185X9020A2	Sprague
2441	C16	9-35 pF, 500 V, Type 538-002	Erie
2535	C17	0.01 μF, Type BYA-6S1	Cornell-Dubilier
2228	C18	50 pF, ±5%, 500 V, Type CM-15	Arco
9568	C19	100 μF, 10%, 20 V, Type 150D476X9020R2	Sprague
2592	C20	1000 pF, 10%, 1000 V, Type CCD-102	Arco
2441	C25	9-35 pF, 500 V, Type 538-002	Erie
8116	C26	15 pF, 5%, 500 V, Type QC	Quality Components
2441	C27	9-35 pF, 500 V, Type 538-002	Erie
9569	C35	22 μF, 10%, 20 V.	Sprague
9569	C36	22 μF, 10%, 20 V.	Sprague
7819	C37	1.8 μF, ±10%, 20 V, Type 150D185X9020A2	Sprague
2583	C38	1000 pF, 500 V, Type SB4A	Allen-Bradley
2583	C39	1000 pF, 500 V, Type SB4A	Allen-Bradley
7819	C40	1.8 μF, ±10%, 20 V, Type 150D185X9020A2	Sprague
7840	C41	0.47 μF, ±10%, 35 V, Type 150D474X9035A2	Sprague
7840	C42	0.47 μF, ±10%, 35 V, Type 150D474X9035A2	Sprague
7840	C43	0.47 μF, ±10%, 35 V, Type 150D474X9035A2	Sprague
7840	C44	0.47 μF, ±10%, 35 V, Type 150D474X9035A2	Sprague
7820	C45	400 μF, −10% +50%, 16 V, Type C437AR/E400	Amperex
or 7821	C45	400 μF, −10% +75%, 15 V, Type 34D407G015GE2	Sprague
2394	C46	0.1 μF, 5%, 200 V, Type 192P	Sprague
7820	C47	400 μF, −10% +50%, 16 V, Type C437AR/E400	Amperex
or 7821	C47	400 μF, −10% +75%, 15 V, Type 34D407G015GE2	Sprague
2593	C48	50 pF, 10%, 1000 V, Type CCD-500	Arco
2592	C49	1000 pF, 10%, 1000 V, Type CCD-102	Arco
8118	C50	0.0068 μF, 5%, 200 V, Type 192P	Sprague
7814	C51	1 μF, −10% +75%, 12 V, Type 30D	Sprague
7814	C52	1 μF, −10% +75%, 12 V, Type 30D	Sprague
7843	C53	75 μF, −10% +50%, 15 V, Type 30D756F015CC4	Sprague
2592	C54	1000 pF, 10%, 1000 V, Type CCD-102	Arco
7816	C55	47 μF, 10%, 20 V, Type 150D476X9020R2	Sprague

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-06.

B. L. Part No.	Circuit Symbol	Capacitors	Manufacturer
2592	C56	1000 pF, 10%, 1000 V, Type CCD-102	Arco
2394	C57	0.1 μF, 5%, 200 V, Type 192P	Sprague
2592	C58	1000 pF, 10%, 1000 V, Type CCD-102	Arco
7836	C62	100 μF, −10% +50%, 64 V, Type C437AR/H100	Amperex
or 7837	C62	100 μF, −10% +75%, 50 V, Type 30D107G050DH4	Sprague
2354	C65	0.15 μF, 10%, 200 V, Type 192P	Sprague
2354	C66	0.15 μF, 10%, 200 V, Type 192P	Sprague
2264	C67*	500 pF, 5%, 300 V, Type DM-15-501-J	Arco
		Resistors	
6070	R1	1 MΩ, 1%, Type MF6C	Electra
6070	R2	1 MΩ, 1%, Type MF6C	Electra
1672	R3	100 Ω, 1%, Type N-20	Corning
6070	R4[1]	1 MΩ, 1%, Type MF6C	Electra
6070	R5[1]	1 MΩ, 1%, Type MF6C	Electra
6076	R6[1]	20.2 kΩ, 1%, Type MF5C	Electra
6070	R7[2]	1 MΩ, 1%, Type MF6C	Electra
6070	R8[2]	1 MΩ, 1%, Type MF6C	Electra
6076	R9[2]	20.2 kΩ, 1%, Type MF5C	Electra
6078	R10[2]	202 Ω, 1%, Type MF5C	Electra
1057	R15	1 kΩ, 5%, Type EB	Allen-Bradley
1327	R16	5 kΩ, 1%, Type CPX-½	Aerovox
1338	R17*	1 kΩ, 1%, Type CPX-½	Aerovox
2706	R18	25 Ω, 1%, Type CPX-½	Aerovox
1305	R19	200 kΩ, 1%, Type CPX-½	Aerovox
1117	R21	10 Ω, 5%, Type EB	Allen-Bradley
1054	R22	2 kΩ, 5%, Type EB	Allen-Bradley
1338	R23	1 kΩ, 1%, Type CPX-½	Aerovox
1074	R24	30 Ω, 5%, Type EB	Allen-Bradley
1044	R25	10 kΩ, 5%, Type EB	Allen-Bradley
1338	R26	1 kΩ, 1%, Type CPX-½	Aerovox
1083	R27	82 Ω, 5%, Type EB	Allen-Bradley
1066	R35	160 Ω, 5%, Type EB	Allen-Bradley
1954	R36	10 kΩ, ±20%, Type X201	CTS
6073	R37[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6073	R38[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6073	R39[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6074	R40[3]	92.5 Ω, 1%, Type MF5C	Ballantine
6074	R41[3]	92.5 Ω, 1%, Type MF5C	Ballantine
6075	R42[3]	63.25 Ω, 1%, Type MF5C	Ballantine

*In some instruments the component listed may not be used at all or its value may differ from the value shown.

[1] Resistors R4, R5, R6 are part of a matched set and must be purchased as Set No. 8859.
[2] Resistors R7, R8, R9, R10 are part of a matched set and must be purchased as Set No. 8860.
[3] Resistors R37, R38, R39, R40, R41, R42 are part of a matched set and must be purchased as Set No. 8858.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-06.

B. L. Part No.	Circuit Symbol	Resistors	Manufacturer
8861	R45	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
8861	R46	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
8861	R47	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
8861	R48	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
1083	R50	82 Ω, 5%, Type EB	Allen-Bradley
1098	R51	120 Ω, 5%, Type EB	Allen-Bradley
1231	R52	200 Ω, 5%, Type CB	Allen-Bradley
1320	R53	20 kΩ, 1%, Type CPX-½	Aerovox
2685	R54	10 Ω, 1%, Type CPX-½	Aerovox
1014	R55	510 kΩ, 5%, Type EB	Allen-Bradley
1040	R56	20 kΩ, 5%, Type EB	Allen-Bradley
6867	R57	10 Ω, ±10%, Type 115	CTS
1021	R58	270 kΩ, 5%, Type EB	Allen-Bradley
1017	R59	390 kΩ, 5%, Type EB	Allen-Bradley
1358	R60*	60 Ω, 1%, Type CPX-½	Aerovox
1065	R61	200 Ω, 5%, Type EB	Allen-Bradley
8455	R62	3.5 Ω, 1%, Type M61	Mepco
1036	R63	33 kΩ, 5%, Type EB	Allen-Bradley
6854	R64	10 kΩ, ±10%, Type 115	CTS
1019	R65	330 kΩ, 5%, Type EB	Allen-Bradley
8852	R66	54.5 kΩ, 1%, Type MF6C	Electra
2732	R67	1.58 kΩ, 1%, Type CPX-½	Aerovox
6861	R68	200 Ω, ±10%, Type 115	CTS
7250	R69	10.4 MΩ, 1%, Type MF72C	Electra
7250	R70	10.4 MΩ, 1%, Type MF72C	Electra
1054	R76	2 kΩ, 5%, Type EB	Allen-Bradley
1489	R77	51 Ω, 2%, Type C32	Corning
6867	R78	10 Ω, ±10%, Type 115	CTS
1097	R79	47 Ω, 5%, Type EB	Allen-Bradley
6854	R85	10 kΩ, ±10%, Type 115	CTS
6854	R86	10 kΩ, ±10%, Type 115	CTS
7261	R87	45.6 kΩ, 1%, Type MF7C	Electra
7261	R88	45.6 kΩ, 1%, Type MF7C	Electra
1111	R89	1.8 kΩ, 5%, Type EB	Allen-Bradley
1111	R90	1.8 kΩ, 5%, Type EB	Allen-Bradley
1098	R91	120 Ω, 5%, Type EB	Allen-Bradley
1098	R92	120 Ω, 5%, Type EB	Allen-Bradley
2734	R93	15 Ω, 1%, Type CPX-½	Aerovox
1072	R94*	39 Ω, 5%, Type EB	Allen-Bradley

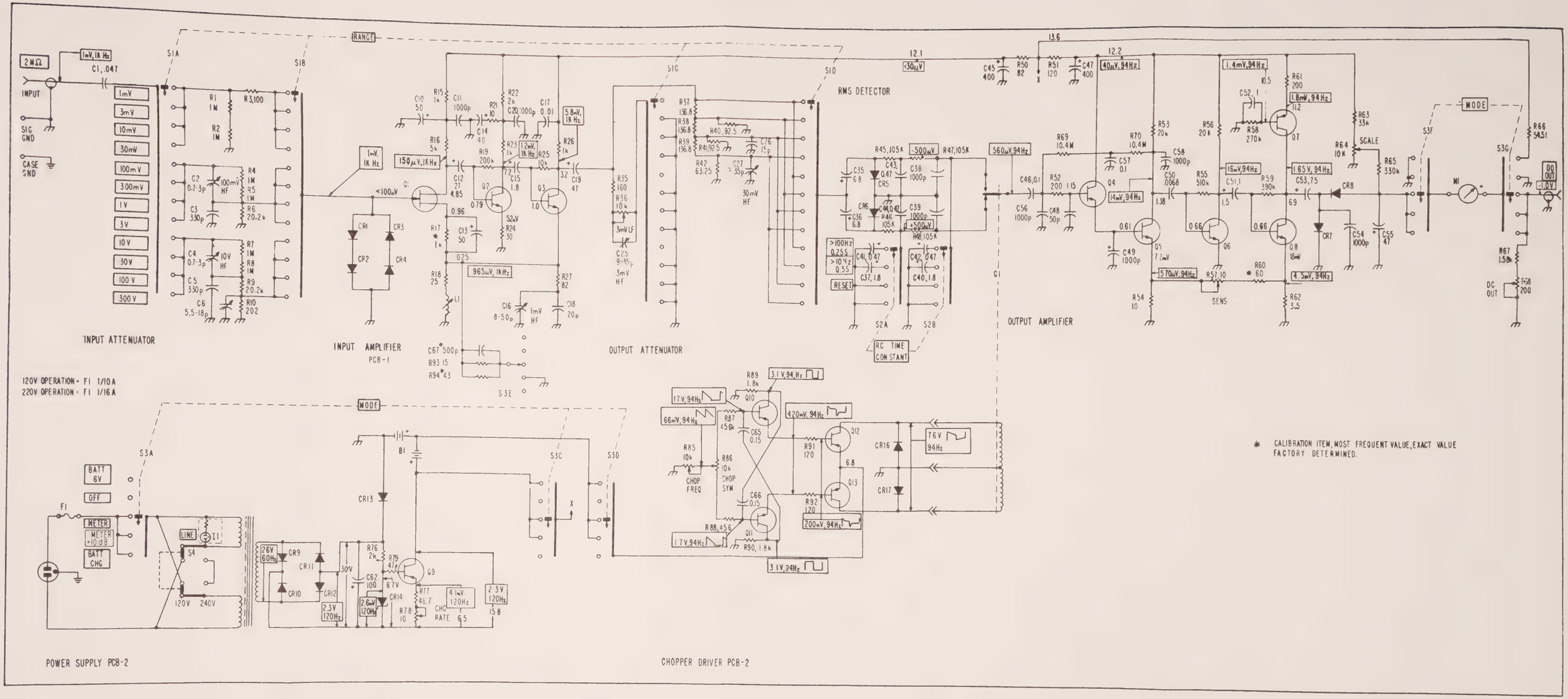
*In some instruments the component listed may not be used at all or its value may differ from the value shown.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-06.

B. L. Part No.	Circuit Symbol	Other Components	Manufacturer
8603	B1	Battery, 12 V, 6 V Tap, 1.2 AH, Type MP	Ballantine
7920	CR1	Diode, Type 1N4148	General Electric
7920	CR2	Diode, Type 1N4148	General Electric
7920	CR3	Diode, Type 1N4148	General Electric
7920	CR4	Diode, Type 1N4148	General Electric
7924	CR5	Diode, Unitunnel, Type HU5A, Selected	Ballantine
7924	CR6	Diode, Unitunnel, Type HU5A, Selected	Ballantine
7920	CR7	Diode, Type 1N4148	General Electric
7920	CR8	Diode, Type 1N4148	General Electric
7921	CR9	Rectifier, Silicon, Type 36591	Ballantine
7921	CR10	Rectifier, Silicon, Type 36591	Ballantine
7921	CR11	Rectifier, Silicon, Type 36591	Ballantine
7921	CR12	Rectifier, Silicon, Type 36591	Ballantine
7921	CR13	Rectifier, Silicon, Type 36591	Ballantine
7910	CR14	Diode, Zener, Type 1N957B, ±5%, 6.8 V	Hughes
7920	CR16	Diode, Type 1N4148	General Electric
7920	CR17	Diode, Type 1N4148	General Electric
2810	F1	Fuse, 1/10 A, Slo-Blo, for 120 V operation, Type 313 100, 3AG	Littelfuse
or 2806	F1	Fuse, 1/16 A, Slo-Blo, for 240 V operation, Type 313 062, 3AG	Littelfuse
3099	G1	Chopper, 6.3 V, Type 33A-6B	Airpax
3490	I1	Pilot Light, Type 2110A1	Industrial Devices
6267	L1	Inductor, Special	Ballantine
7933	Q1	Transistor, Type 2N4221A, Selected*	Ballantine
7926	Q2	Transistor, Type 2N3563, Selected*	Ballantine
7926	Q3	Transistor, Type 2N3563, Selected*	Ballantine
7938	Q4	Transistor, Type A322, Selected*	Ballantine
7938	Q5	Transistor, Type A322, Selected*	Ballantine
7938	Q6	Transistor, Type A322, Selected*	Ballantine
7927	Q7	Transistor, Type 2N3638, Selected*	Ballantine
7938	Q8	Transistor, Type A322, Selected*	Ballantine
7929	Q9	Transistor, Type 2N555	Motorola
7927	Q10	Transistor, Type 2N3638	Fairchild
7927	Q11	Transistor, Type 2N3638	Fairchild
7927	Q12	Transistor, Type 2N3638	Fairchild
7927	Q13	Transistor, Type 2N3638	Fairchild
6024	M1	Microammeter, Logarithmic Type, 60 - 600 μA	Ballantine
7765	S1	Switch, Range, Special	Ballantine
7766	S2	Switch, Time Constant, Special	Ballantine
7782	S3	Switch, Mode, Special	Ballantine
7775	S4	Switch, Slide, Type G126-PC	Continental Wirt
6262	T1	Transformer, Power, Special	Ballantine

*If replacement of selected transistors is necessary, order from Ballantine giving type, symbol, designation (Q1, Q2, etc.) and color code (center dot, side dot, etc.) if any.



CAPACITORS: NOT MARKED — MICROFARADS (10^{-6}F)
P — PICOFARADS (10^{-12}F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3}Ω)
M — MEGOHMS (10^{6}Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3}V)

ALL DC, AC VOLTAGES MEASURED WITH REFERENCE TO SIGNAL GROUND UNLESS OTHERWISE INDICATED

* CALIBRATION ITEM, MOST FREQUENT VALUE, EXACT VALUE FACTORY DETERMINED.

Fig. B-3. Schematic and Parts List, Model 323-06 (Serial No. 101-2194)

REPLACEMENT PARTS LIST

NOTE: This replacement parts list applies only to the Model 323-07.

B. L. Part No.	Circuit Symbol	Capacitors	Manufacturer
8138	C1	0.150 μF, 600 V, 10%	Sprague
2454	C2	0.7-3.0 pF, 350 V, Type 535-000	Erie
2282	C3	330 pF, 5%, 500 V, Type 653-015	Erie
2454	C4	0.7-3.0 pF, 350 V, Type 535-000	Erie
2282	C5	330 pF, 5%, 500 V, Type 653-015	Erie
2442	C6	2-8 pF, 200 V, Type 538-002 NPO	Erie
2096	C10	50 μF, −10% +75%, 15 V, Type 30D	Sprague
2592	C11	1000 pF, 10%, 1000 V, Type CCD-102	Arco
9376	C12	250 μF, 10%, 15 V, 10%	Sprague
2085	C13	150 μF, −10% +75%, 6 V, Type 30D	Sprague
7843	C14	75 μF, −10% +50%, 15 V, Type C426AR/G32	Amperex
2785	C15	6.8 μF, ±10%, 35 V, Type 150D185X9020A2	Sprague
2441	C16	9-35 pF, 500 V, Type 538-002	Erie
2535	C17	0.01 μF, Type BYA-6S1	Cornell-Dubilier
2228	C18	50 pF, ±5%, 500 V, Type CM-15	Arco
9568	C19	100 μF, 10%, 20 V, Type 150D476X9020R2	Sprague
2592	C20	1000 pF, 10%, 1000 V, Type CCD-102	Arco
2441	C25	9-35 pF, 500 V, Type 538-002	Erie
8116	C26	15 pF, 5%, 500 V, Type QC	Quality Components
2441	C27	9-35 pF, 500 V, Type 538-002	Erie
9569	C35	22 μF, 10%, 15 V, 10%	Sprague
9569	C36	22 μF, 10%, 15 V, 10%	Sprague
7819	C37	1.8 μF, ±10%, 20 V, Type 150D185X9020A2	Sprague
2583	C38	1000 pF, 500 V, Type SB4A	Allen-Bradley
2583	C39	1000 pF, 500 V, Type SB4A	Allen-Bradley
7819	C40	1.8 μF, ±10%, 20 V, Type 150D185X9020A2	Sprague
7840	C41	0.47 μF, ±10%, 35 V, Type 150D474X9035A2	Sprague
7840	C42	0.47 μF, ±10%, 35 V, Type 150D474X9035A2	Sprague
7840	C43	0.47 μF, ±10%, 35 V, Type 150D474X9035A2	Sprague
7840	C44	0.47 μF, ±10%, 35 V, Type 150D474X9035A2	Sprague
7820	C45	400 μF, −10% +50%, 16 V, Type C437AR/E400	Amperex
or 7821	C45	400 μF, −10% +75%, 15 V, Type 34D407G015GE2	Sprague
2394	C46	0.1 μF, 5%, 200 V, Type 192P	Sprague
7820	C47	400 μF, −10% +50%, 16 V, Type C437AR/E400	Amperex
or 7821	C47	400 μF, −10% +75%, 15 V, Type 34D407G015GE2	Sprague
2593	C48	50 pF, 10%, 1000 V, Type CCD-500	Arco
2592	C49	1000 pF, 10%, 1000 V, Type CCD-102	Arco
8118	C50	0.0068 μF, 5%, 200 V, Type 192P	Sprague
7814	C51	1 μF, −10% +75%, 12 V, Type 30D	Sprague
7814	C52	1 μF, −10% +75%, 12 V, Type 30D	Sprague
7843	C53	75 μF, −10% +50%, 15 V, Type 30D756F015CC4	Sprague
2592	C54	1000 pF, 10%, 1000 V, Type CCD-102	Arco
7816	C55	47 μF, 10%, 20 V, Type 150D476X9020R2	Sprague
2592	C56	1000 pF, 10%, 1000 V, Type CCD-102	Arco

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-07.

B. L. Part No.	Circuit Symbol	Resistors	Manufacturer
6074	R41[3]	92.5 Ω, 1%, Type MF5C	Ballantine
6075	R42[3]	63.25 Ω, 1%, Type MF5C	Ballantine
8861	R45	105 kΩ, 1%, Type MF5C, CHAR D	Electra
8861	R46	105 kΩ, 1%, Type MF5C, CHAR D	Electra
8861	R47	105 kΩ, 1%, Type MF5C, CHAR D	Electra
8861	R48	105 kΩ, 1%, Type MF5C, CHAR. D	Electra
1083	R50	82 Ω, 5%, Type EB	Allen-Bradley
1098	R51	120 Ω, 5%, Type EB	Allen-Bradley
1231	R52	200 Ω, 5%, Type CB	Allen-Bradley
1320	R53	20 kΩ, 1%, Type CPX-½	Aerovox
2685	R54	10 Ω, 1%, Type CPX-½	Aerovox
1014	R55	510 kΩ, 5%, Type EB	Allen-Bradley
1040	R56	20 kΩ, 5%, Type EB	Allen-Bradley
6867	R57	10 Ω, ±10%, Type 115	CTS
1021	R58	270 kΩ, 5%, Type EB	Allen-Bradley
1017	R59	390 kΩ, 5%, Type EB	Allen-Bradley
1358	R60*	60 Ω, 1%, Type CPX-½	Aerovox
1065	R61	200 Ω, 5%, Type EB	Allen-Bradley
8455	R62	3.5 Ω, 1%, Type M61	Mepco
1036	R63	33 kΩ, 5%, Type EB	Allen-Bradley
6854	R64	10 kΩ, ±10%, Type 115	CTS
1019	R65	330 kΩ, 5%, Type EB	Allen-Bradley
2732	R67	1.58 kΩ, 1%, CPX-½	Aerovox
6861	R68	200 Ω, ±10%, Type 115	CTS
7250	R69	10.4 MΩ, 1%, Type MF72C	Electra
7250	R70	10.4 MΩ, 1%, Type MF72C	Electra
8026	R76	430 Ω, 5%, Type PW3	IRC
1094	R77	2.4 kΩ, 5%, Type EB	Allen-Bradley
1094	R78	2.4 kΩ, 5%, Type EB	Allen-Bradley
6854	R85	10 kΩ, ±10%, Type 115	CTS
6854	R86	10 kΩ, ±10%, Type 115	CTS
7261	R87	45.6 kΩ, 1%, Type MF7C	Electra
7261	R88	45.6 kΩ, 1%, Type MF7C	Electra
1111	R89	1.8 kΩ, 5%, Type EB	Allen-Bradley
1111	R90	1.8 kΩ, 5%, Type EB	Allen-Bradley
1098	R91	120 Ω, 5%, Type EB	Allen-Bradley
1098	R92	120 Ω, 5%, Type EB	Allen-Bradley
2734	R93	15 Ω, 1%, Type CPX-½	Aerovox
1072	R94*	39 Ω, 5%, Type EB	Allen-Bradley

*In some instruments the component listed may not be used at all or its value may differ from the value shown.

[3]Resistors R37, R38, R39, R40, R41, R42 are part of a matched set and must be purchased as Set No. 8858.

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-07.

B. L. Part No.	Circuit Symbol	Capacitors	Manufacturer
2394	C57	0.1 μF, 5%, 200 V, Type 192P	Sprague
2592	C58	1000 pF, 10%, 1000 V, Type CCD-102	Arco
7836	C62	100 μF, −10% +50%, 64 V, Type C437AR/H100	Amperex
or 7837	C62	100 μF, −10% +75%, 50 V, Type 30D107G050DH4	Sprague
2096	C63	50 μF, −10% +75%, 15 V, Type 30D	Sprague
7824	C64	250 μF, −10% +75%, 50 V, Type 39D257G050HE4	Sprague
or 7825	C64	250 μF, −10% +50%, 64 V, Type C437AR/H250	Amperex
2354	C65	0.15 μF, 10%, 200 V, Type 192P	Sprague
2354	C66	0.15 μF, 10%, 200 V, Type 192P	Sprague
2264	C67*	500 pF, 5%, 300 V, Type DM-15-501-J	Arco
		Resistors	
6070	R1	1 MΩ, 1%, Type MF6C	Electra
6070	R2	1 MΩ, 1%, Type MF6C	Electra
1672	R3	100 Ω, 1%, Type N-20	Corning
6070	R4[1]	1 MΩ, 1%, Type MF6C	Electra
6070	R5[1]	1 MΩ, 1%, Type MF6C	Electra
6076	R6[1]	20.2 kΩ, 1%, Type MF5C	Electra
6070	R7[2]	1 MΩ, 1%, Type MF6C	Electra
6070	R8[2]	1 MΩ, 1%, Type MF6C	Electra
6076	R9[2]	20.2 kΩ, 1%, Type MF5C	Electra
6078	R10[2]	202 Ω, 1%, Type MF5C	Electra
1057	R15	1 kΩ, 5%, Type EB	Allen-Bradley
1327	R16	5 kΩ, 1%, Type CPX-½	Aerovox
1338	R17*	1 kΩ, 1%, Type CPX-½	Aerovox
2706	R18	25 Ω, 1%, Type CPX-½	Aerovox
1305	R19	200 kΩ, 1%, Type CPX-½	Aerovox
1117	R21	10 Ω, 5%, Type EB	Allen-Bradley
1054	R22	2 kΩ, 5%, Type EB	Allen-Bradley
1338	R23	1 kΩ, 1%, Type CPX-½	Aerovox
1074	R24	30 Ω, 5%, Type EB	Allen-Bradley
1044	R25	10 kΩ, 5%, Type EB	Allen-Bradley
1338	R26	1 kΩ, 5±, Type CPX-½	Aerovox
1083	R27	82 Ω, 5%, Type EB	Allen-Bradley
1066	R35	160 Ω, 5%, Type EB	Allen-Bradley
1954	R36	10 kΩ, ±20%, Type X201	CTS
6073	R37[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6073	R38[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6073	R39[3]	136.8 Ω, 1%, Type MF5C	Ballantine
6074	R40[3]	92.5 Ω, 1%, Type MF5C	Ballantine

*In some instruments the component listed may not be used at all or its value may differ from the value shown.

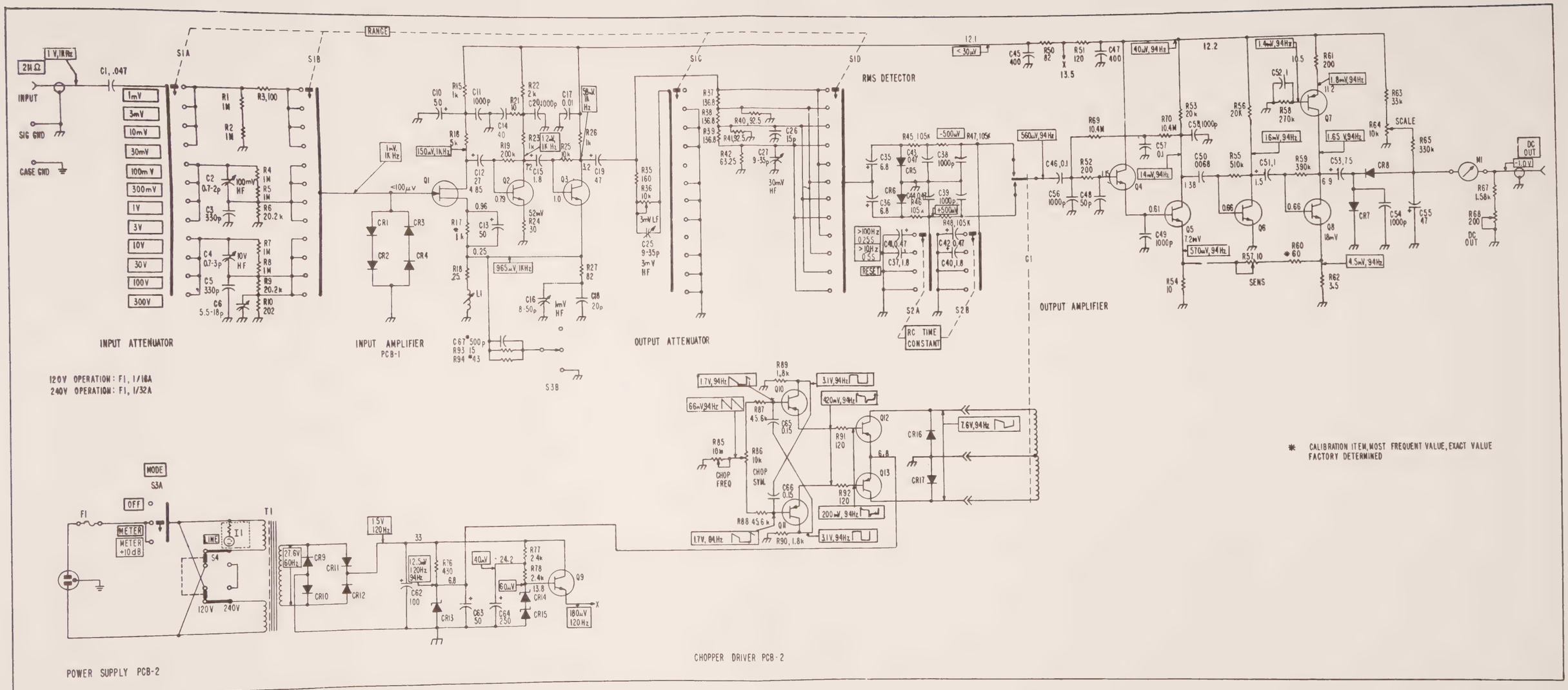
[1]Resistors R4, R5, R6 are part of a matched set and must be purchased as Set No. 8859.
[2]Resistors R7, R8, R9, R10 are part of a matched set and must be purchased as Set No. 8860
[3]Resistors R37, R38, R39, R40, R41, R42 are part of a matched set and must be purchased as Set No. 8858

REPLACEMENT PARTS LIST (Continued)

NOTE: This replacement parts list applies only to the Model 323-07.

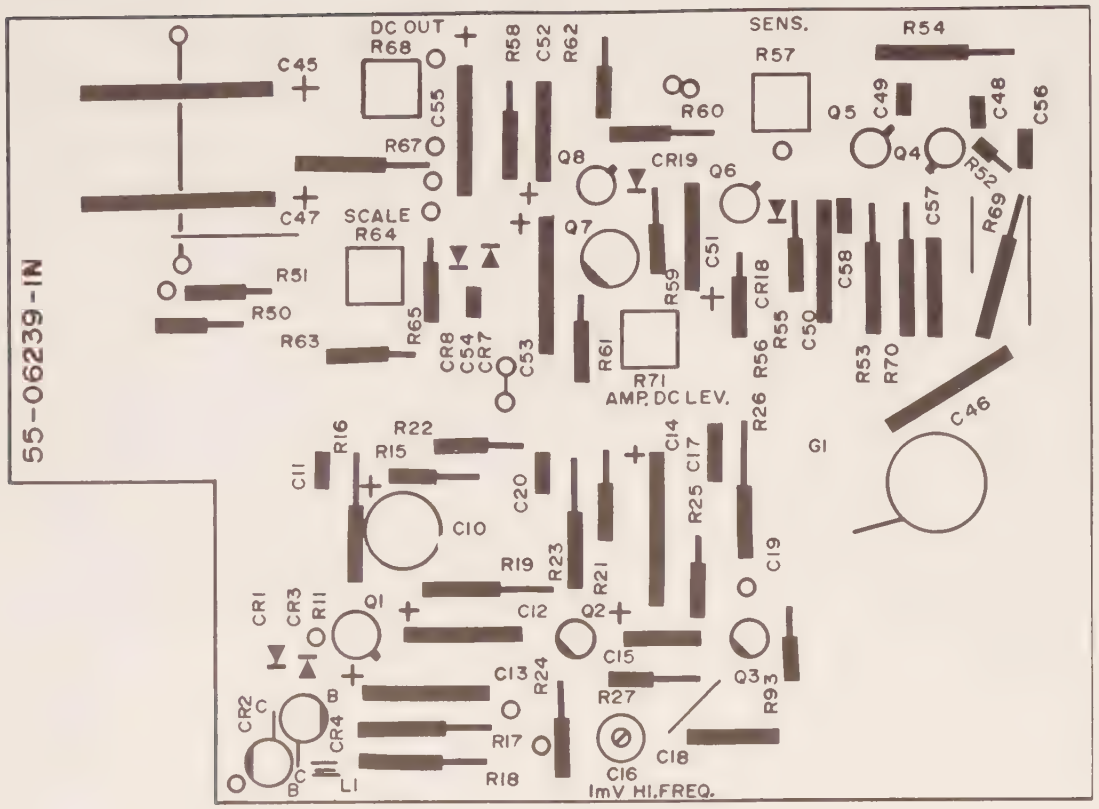
B. L. Part No.	Circuit Symbol	Other Components	Manufacturer
7920	CR1	Diode, Type 1N4148	General Electric
7920	CR2	Diode, Type 1N4148	General Electric
7920	CR3	Diode, Type 1N4148	General Electric
7920	CR4	Diode, Type 1N4148	General Electric
7924	CR5	Diode, Unitunnel, Type HU5A, Selected	Ballantine
7924	CR6	Diode, Unitunnel, Type HU5A, Selected	Ballantine
7920	CR7	Diode, Type 1N4148	General Electric
7920	CR8	Diode, Type 1N4148	General Electric
7921	CR9	Rectifier, Silicon, Type 36591	Ballantine
7921	CR10	Rectifier, Silicon, Type 36591	Ballantine
7921	CR11	Rectifier, Silicon, Type 36591	Ballantine
7921	CR12	Rectifier, Silicon, Type 36591	Ballantine
7910	CR13	Diode, Zener, Type 1N957B, ±5%, 6.8 V	Hughes
7910	CR14	Diode, Zener, Type 1N957B, ±5%, 6.8 V	Hughes
7910	CR15	Diode, Zener, Type 1N957B, ±5%, 6.8 V	Hughes
7920	CR16	Diode, Type 1N4148	General Electric
7920	CR17	Diode, Type 1N4148	General Electric
2806	F1	Fuse, 1/16 A, Slo-Blo, for 120 V operation, Type 313.062, 3AG	Littelfuse
or 2811	F1	Fuse, 1/32 A, Slo-Blo, for 240 V operation, Type 313.031, 3AG	Littelfuse
3099	G1	Chopper, 6.3 V, Type 33A-6B	Airpax
3490	I1	Pilot Light, Type 2110A1	Industrial Devices
6267	L1	Inductor, Special	Ballantine
7933	Q1	Transistor, Type 2N4221A, Selected*	Ballantine
7926	Q2	Transistor, Type 2N3563, Selected*	Ballantine
7926	Q3	Transistor, Type 2N3563, Selected*	Ballantine
7938	Q4	Transistor, Type A322, Selected*	Ballantine
7938	Q5	Transistor, Type A322, Selected*	Ballantine
7938	Q6	Transistor, Type A322, Selected*	Ballantine
7927	Q7	Transistor, Type 2N3638, Selected*	Ballantine
7938	Q8	Transistor, Type A322, Selected*	Ballantine
7930	Q9	Transistor, Type 2N3766	Motorola
7927	Q10	Transistor, Type 2N3638	Fairchild
7927	Q11	Transistor, Type 2N3638	Fairchild
7927	Q12	Transistor, Type 2N3638	Fairchild
7927	Q13	Transistor, Type 2N3638	Fairchild
6024	M1	Microammeter, Logarithmic Type, 60 - 600 μA	Ballantine
7765	S1	Switch, Range, Special	Ballantine
7766	S2	Switch, Time Constant, Special	Ballantine
7783	S3	Switch, Mode	Ballantine
7775	S4	Switch, Slide, Type G126-PC	Continental Wirt
6262	T1	Transformer, Power, Special	Ballantine

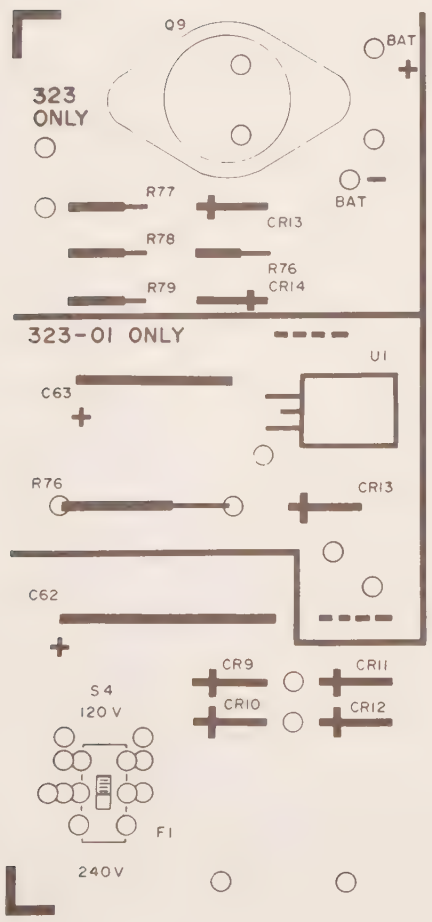
*If replacement of selected transistors is necessary, order from Ballantine giving type, symbol, designation (Q1, Q2, etc.) and color code (center dot, side dot, etc.) if any.

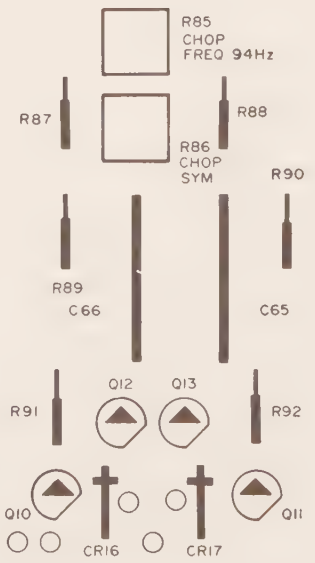


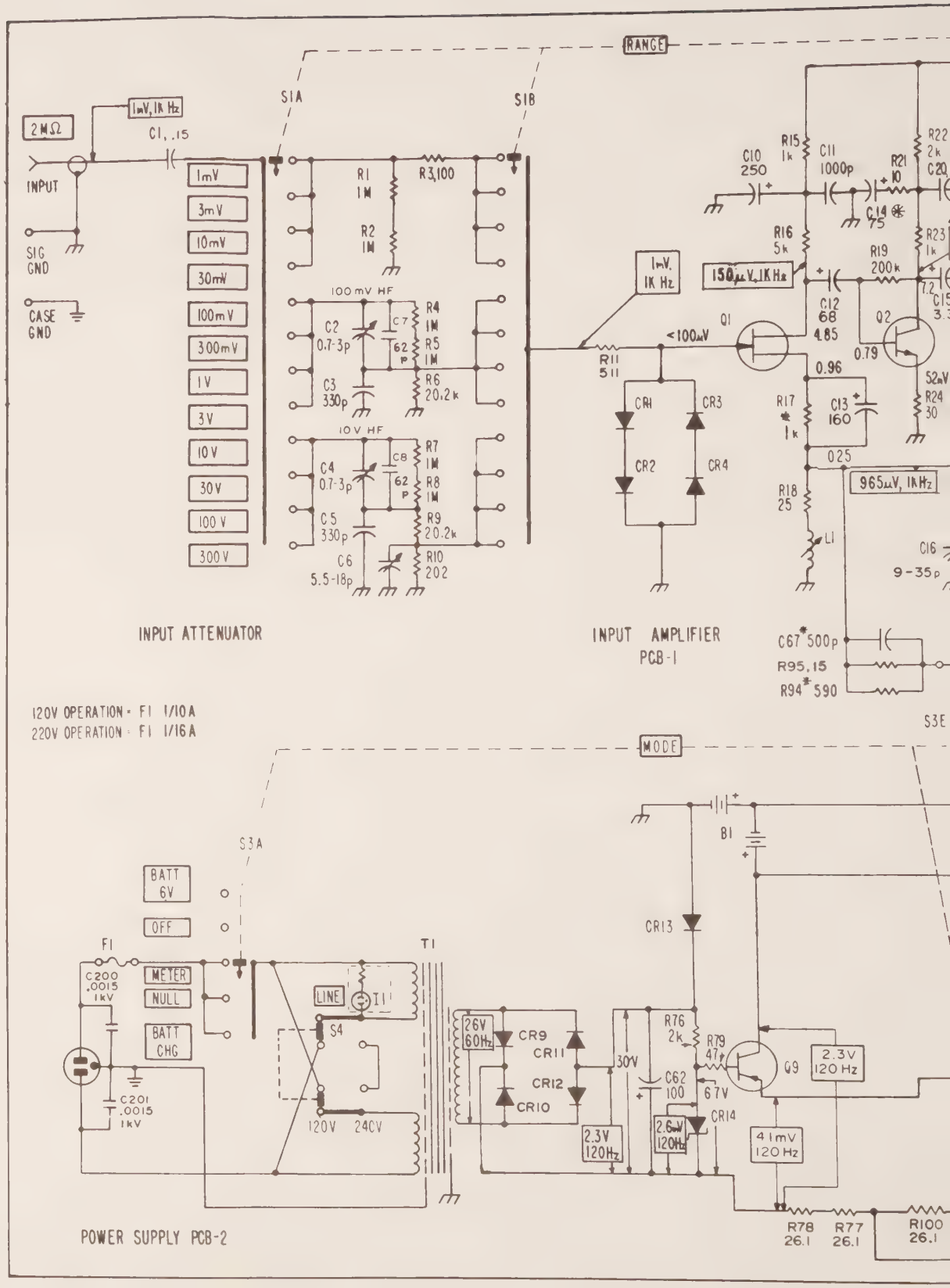
CAPACITORS: NOT MARKED — MICROFARADS (10^{-6}F)
P — PICOFARADS (10^{-12}F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3}Ω)
M — MEGOHMS (10^{6}Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3}V)

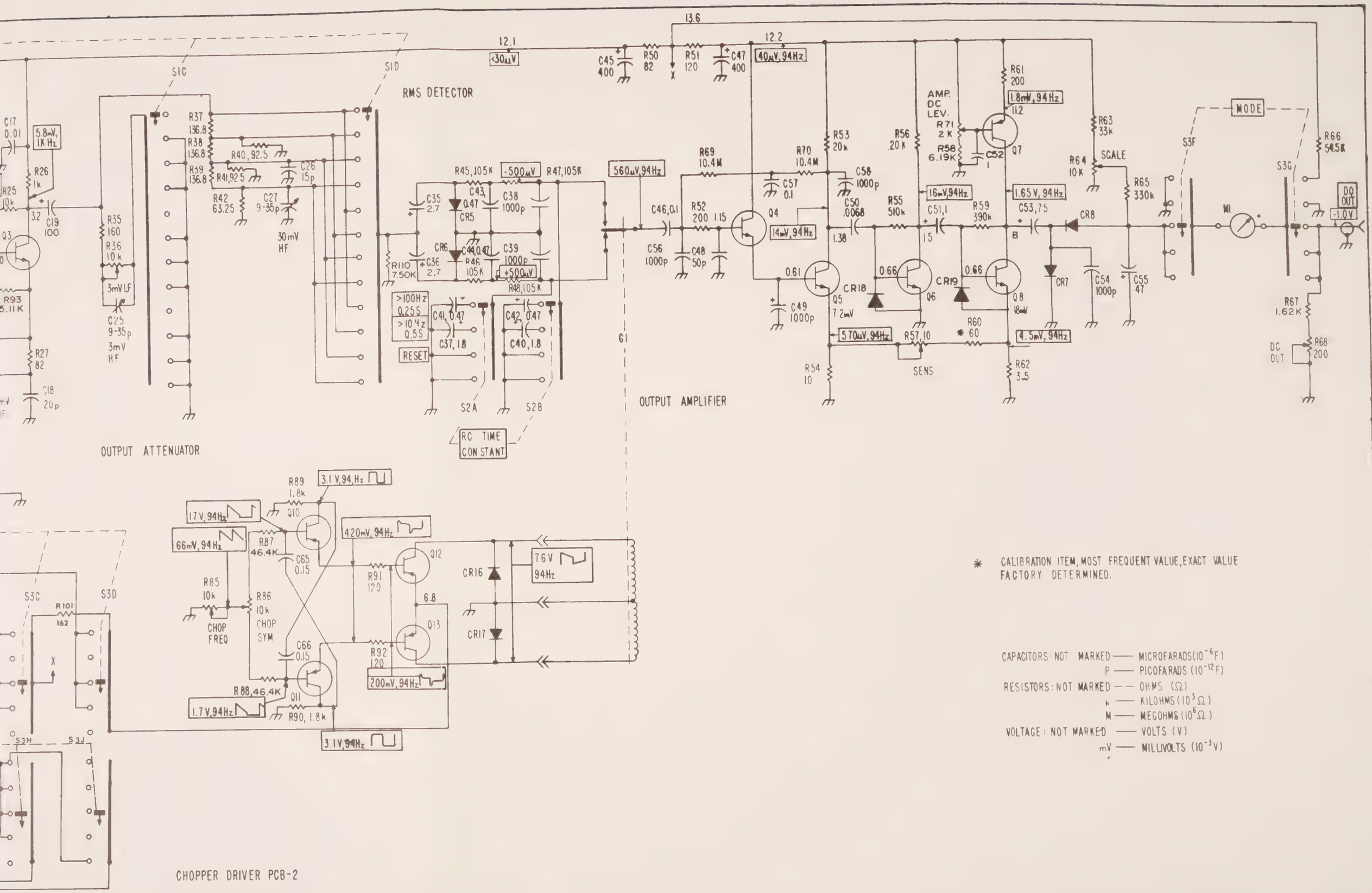
Fig. B-4. Schematic and Parts List, Model 323-07 (Serial No. 101-2194)


55-06239-IN
DC OUT
R68
SENS.
R57
R54
C45
C47
R67
SCALE
R64
R51
R50
R63
R60
Q5
Q4
Q8
Q7
Q6
CR19
CR18
R52
R69
C57
C58
R53
R70
C46
G1
R71
AMP. DC LEV.
C10
C11
R16
R15
R22
C20
R19
R23
R21
C12
Q1
Q2
C14
C17
R25
R26
C19
CR1
CR3
R11
C13
R24
R27
Q3
R93
CR2
CR4
L1
R17
R18
C16
1mV HI. FREQ.
C18


Q9
BAT
323
ONLY
R77
CR13
R78
R76
CR14
R79
323-01 ONLY
U1
C63
R76
CR13
C62
CR9
CR11
CR10
CR12
S4
120 V
F1
240V


R85
CHOP
FREQ 94Hz
R87
R88
R86
CHOP
SYM
R90
R89
C66
C65
R91
Q12
Q13
R92
Q10
Q11
CR16
CR17

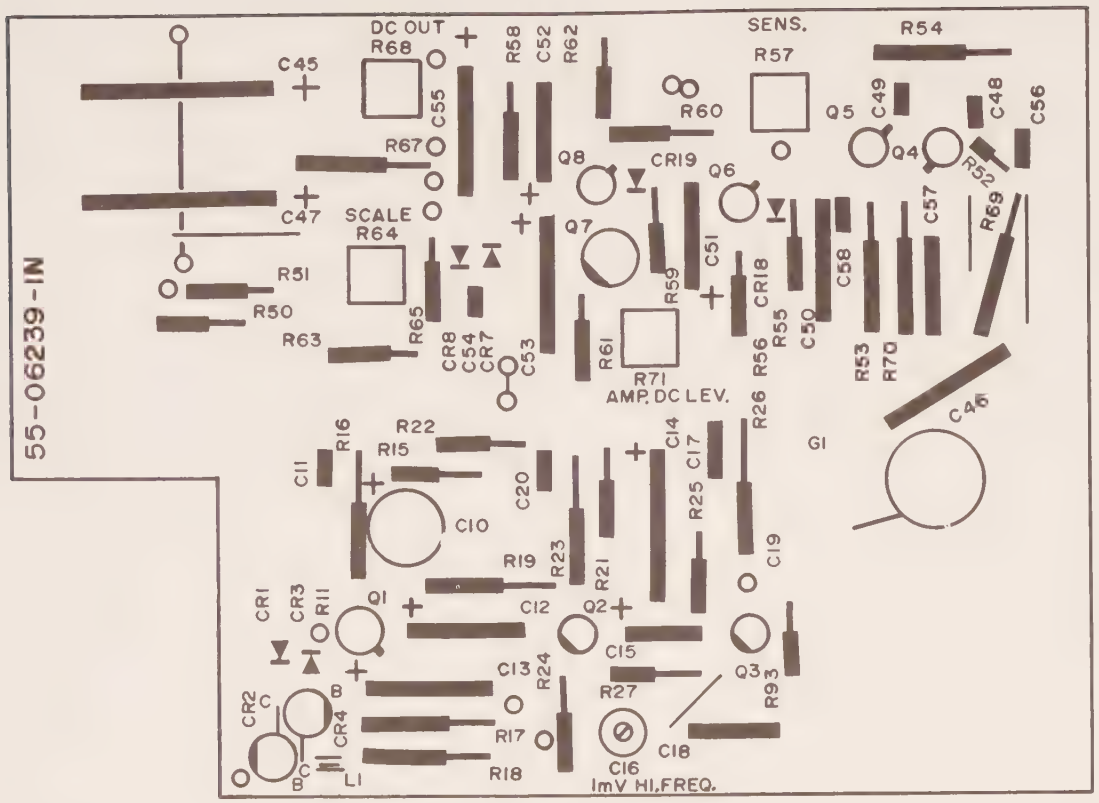

RANGE
S1A
S1B
2MΩ
1mV, 1k Hz
C1, .15
INPUT
SIG GND
CASE GND
1mV
3mV
10mV
30mV
100mV
300mV
1V
3V
10V
30V
100V
300V
R1 1M
R2 1M
R3, 100
100 mV HF
C2 0.7-3p
C7 62 p
R4 1M
R5 1M
C3 330p
R6 20.2k
10V HF
C4 0.7-3p
C8 62 p
R7 1M
R8 1M
C5 330p
R9 20.2k
C6 5.5-18p
R10 202
INPUT ATTENUATOR
R11 511
1mV. 1K Hz
<100μV
Q1
Q2
CR1
CR3
CR2
CR4
C10 250
R15 1k
C11 1000p
R21 10
C14 75
R16 5k
R19 200k
150μV, 1K Hz
C12 68
4.85
0.79
0.96
R17 1k
C13 160
025
965μV, 1k Hz
R18 25
L1
INPUT AMPLIFIER
PCB-1
C67 500p
R95, 15
R94 590
120V OPERATION - F1 1/10A
220V OPERATION - F1 1/16A
MODE
S3A
S3E
BATT 6V
OFF
METER
NULL
BATT CHG
F1
C200 .0015 1kV
C201 .0015 1kV
LINE
T1
S4
120V
240V
B1
CR13
26V 60Hz
CR9
CR11
CR12
CR10
30V
C62 100
2.3V 120Hz
R76 2k
R79 47
Q9
2.3V 120Hz
67V
CR14
2.6V 120Hz
41mV 120Hz
R78 26.1
R77 26.1
R100 26.1
POWER SUPPLY PCB-2

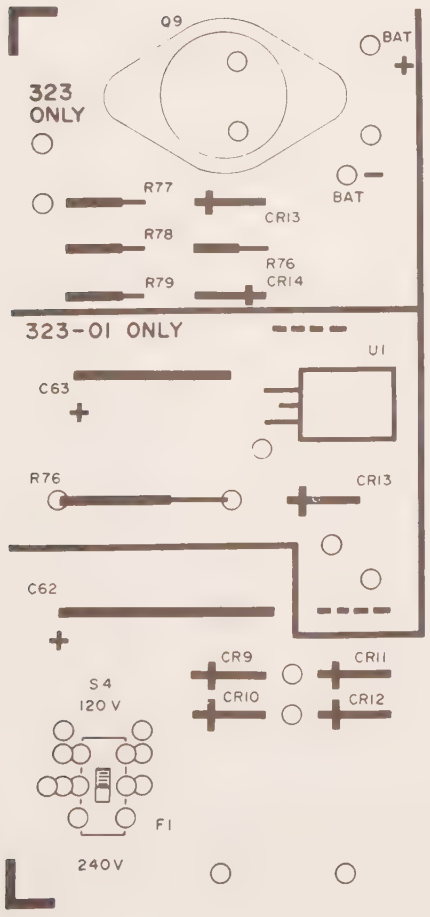


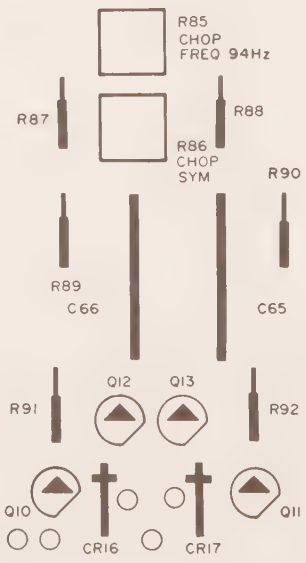
* CALIBRATION ITEM, MOST FREQUENT VALUE, EXACT VALUE FACTORY DETERMINED.

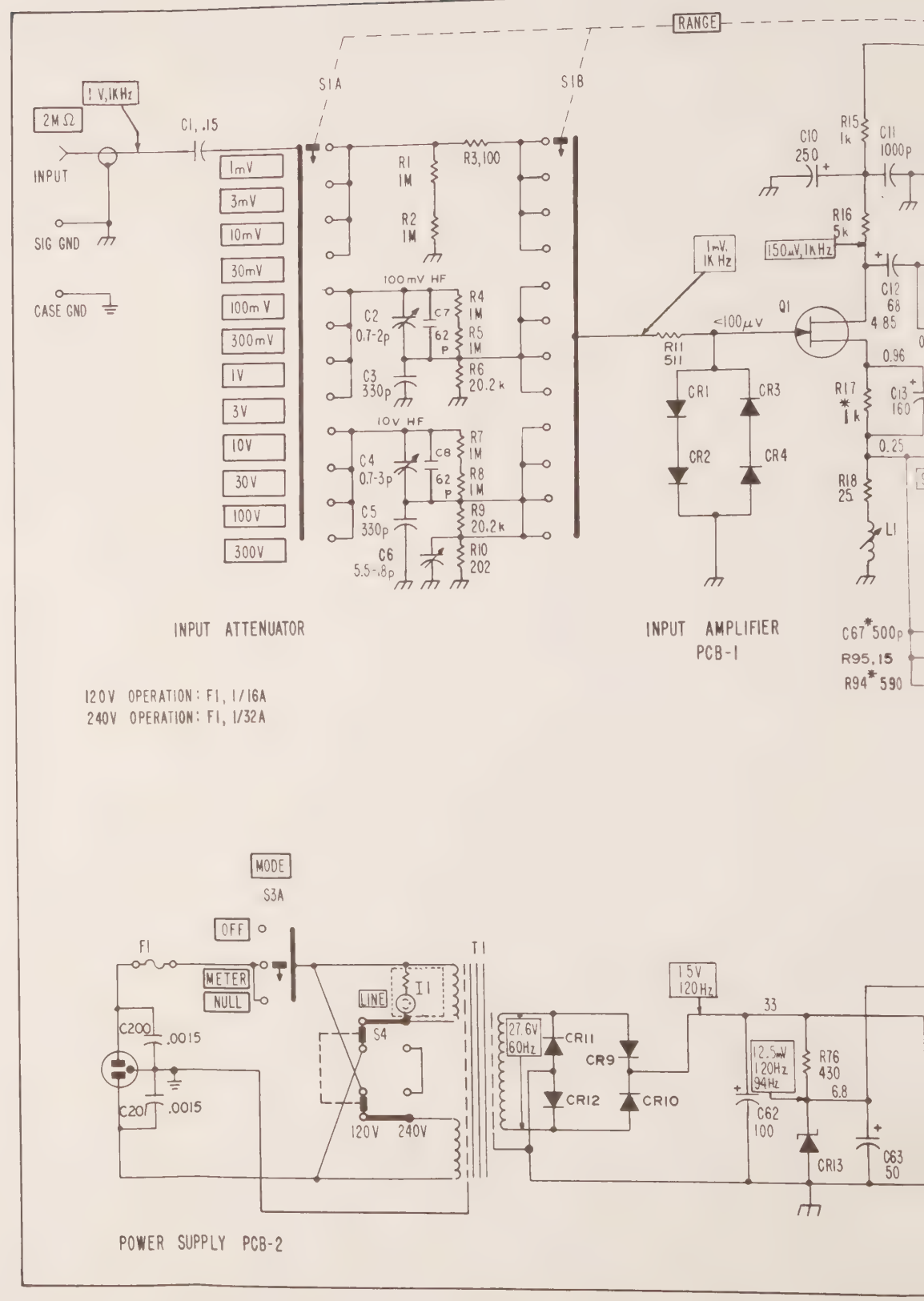
CAPACITORS: NOT MARKED — MICROFARADS (10^{-6}F)
P — PICOFARADS (10^{-12}F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3}Ω)
M — MEGOHMS (10^{6}Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3}V)

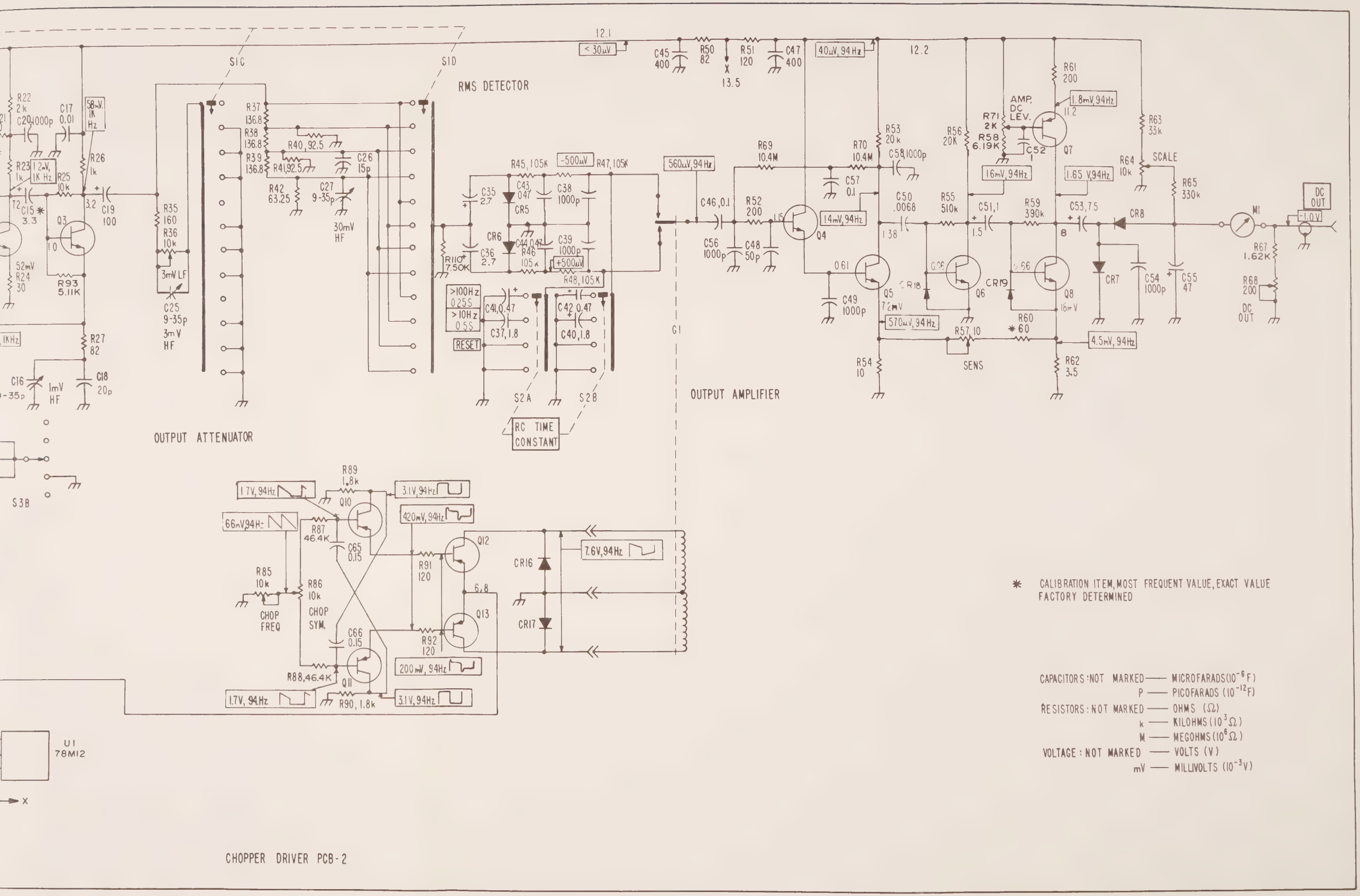
Fig. A-3. Schematic, Model 323-06 (Serial No. 2195 and higher)


55-06239-IN
DC OUT
R68
SENS.
R57
R54
C45
C47
R67
SCALE
R64
R51
R50
R63
R65
CR8
C54
CR7
C53
R58
C52
R62
R60
Q8
CR19
Q6
Q5
Q4
C49
C48
C56
R52
R69
C57
C58
C51
R59
CR18
R56
R55
C50
R53
R70
R61
R71
AMP. DC LEV.
C46
G1
C11
R16
R22
R15
C10
C20
C14
C17
R26
R25
C19
R19
R23
R21
CR1
CR3
R11
Q1
C12
Q2
C15
Q3
R93
C13
R24
R27
R17
R18
CR2
CR4
L1
C16
1mV HI. FREQ.
C18


Q9
BAT
323
ONLY
R77
CR13
R78
R76
CR14
R79
BAT
323-01 ONLY
U1
C63
R76
CR13
C62
CR9
CR11
CR10
CR12
S4
120 V
F1
240V


R85
CHOP
FREQ 94Hz
R87
R88
R86
CHOP
SYM
R90
R89
C66
C65
R91
Q12
Q13
R92
Q10
Q11
CR16
CR17


RANGE
S1A
S1B
1 V, 1KHz
2MΩ
INPUT
SIG GND
CASE GND
C1, .15
1mV
3mV
10mV
30mV
100mV
300mV
1V
3V
10V
30V
100V
300V
R1
1M
R2
1M
R3, 100
100mV HF
C2
0.7-2p
C7
62
P
R4
1M
R5
1M
C3
330p
R6
20.2k
10V HF
C4
0.7-3p
C8
62
P
R7
1M
R8
1M
C5
330p
R9
20.2k
C6
5.5-.8p
R10
202
1mV, 1K Hz
<100μV
150μV, 1KHz
Q1
R11
511
CR1
CR3
CR2
CR4
C10
250
R15
1k
C11
1000p
R16
5k
C12
68
4.85
0.96
R17
*1k
C13
160
0.25
R18
25
L1
C67*500p
R95, 15
R94*590
INPUT ATTENUATOR
INPUT AMPLIFIER
PCB-1
120V OPERATION: F1, 1/16A
240V OPERATION: F1, 1/32A
MODE
S3A
OFF
METER
NULL
F1
T1
LINE
I1
S4
C200
.0015
C201
.0015
120V
240V
27.6V
60Hz
CR11
CR9
CR12
CR10
15V
120Hz
33
12.5mW
120Hz
94Hz
C62
100
R76
430
6.8
CR13
C63
50
POWER SUPPLY PCB-2



* CALIBRATION ITEM, MOST FREQUENT VALUE, EXACT VALUE FACTORY DETERMINED

CAPACITORS: NOT MARKED — MICROFARADS (10^{-6} F)
P — PICOFARADS (10^{-12} F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS (10^{3} Ω)
M — MEGOHMS (10^{6} Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3} V)

Fig. A-4. Schematic, Model 323-07
(Serial No. 2195 and higher)

APPENDIX C

ADDENDUM

to

INSTRUCTION MANUAL

for

TRUE RMS VOLTMETERS

MODEL 323-20, 323-20 MOD 40
MODEL 323-21, 323-21 MOD 40

BALLANTINE LABORATORIES, INC.

P.O. BOX 97, BOONTON, N.J. 07005

90900011C

September 1979

1.1 The Model 323-20 True RMS Voltmeter is the same as the Model 323-06 except the DECIBLE scale on the meter is calibrated in dBv instead of dBm and it is referenced to 1 volt (0 dB = 1 V).

1.2 The Model 323-20 MOD 40 differs from the Model 323-20 in that it is "Environmentalized".

1.3 The Model 323-21 True RMS Voltmeter is the same as the Model 323-07 except the DECIBLE scale on the meter is calibrated in dBv instead of dBm and it is referenced to 1 volt (0 dB = 1 V).

1.4 The Model 323-21 MOD 40 differs from the Model 323-21 in that it is "Environmentalized".

MP MASTER
MA31987

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